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The Early Days of Television

By JOHN V. L. HOGAN

This paper describes the beginnings of television, both in the U.S.A. and abroad. Once there had been formulated the desire to transmit pictorial intelligence, including motion, from one point to another, many ingenious attempts to solve the technical problems were proposed. The paper describes a number of the more significant early steps and points out that although they were broadly successful in obtaining the primary objective of "seeing at a distance," they were limited as to the amount of pictorial matter that could be transmitted.

HUMAN BEINGS, as well as the so-called lower animals, have long had the desire to see what is going on at places beyond their normal range of vision. It takes no Sherlock Holmes to deduce that when a dog stops running after something and sits up on his haunches, peering ahead attentively, he is impelled by some urge to see more than he could have seen if he had kept his forefeet on the ground. This same urge for expanded vision had certainly been felt by others than our canine friends. Maybe it explains why the giraffe and the ostrich grew long necks. However, except perhaps for the development of an erect posture, the human species seems to have attempted to extend its range of vision without falling back on biology or physical evolution. In order "to get a better view" of something or other, we first climbed trees. I have not been able to fix the earliest date when humans decided that they would prefer themselves to see what was going on beyond their normal limits of visual observation, rather than to be told about it by someone else. I suspect that our species made that decision a long time ago. Perhaps it has come down to us from Adam and Eve.

The first suggestions that machinery could be built to accomplish the miracle of seeing what was happening somewhere else were made many years later. Probably the first contribution to the solution was purely optical, coming into being with the invention of the equivalent of field glasses, about 1600 A.D. It had long been known that if a man stood on a mountain and looked into a valley or to another nearby mountain, he could see more of what was going on there than if he had stayed home. He could see large objects or mass movements, but he could not see much detail. So the optical experts came up with the ancient telescope, which supplemented the lenses of the observer's own eyes. With such an optical aid, he could see more detail, but only in a restricted field. Still he was unable to look around a corner, unless he could persuade somebody to set up a mirror at the strategic time and place.

This human desire to see what was going on somewhere beyond the range of normal vision, and even around corners, led to our modern science of television. The first machines that carried us forward to television were probably those described by Bain in 1842 and by Bakewell in 1847. These inventors proposed schemes for the electrical transmission of still pictures from one point to another. Their systems provided for "seeing at a distance" or "seeing by electricity" in a limited sense, for they transmitted visual information over a telegraph line which could extend for a considerable distance and could go around almost any number of corners. However, the machines could handle only one view at a time and very slowly at that. Therefore, they could not reproduce motion, which is an essential part of complete vision. Bain and Bakewell laid the foundation for the modern facsimile transmission of text and pictures, and they introduced the process of synchronous sequential scanning which is now used in both facsimile and television, but their mechanical light-sensing devices were too crude to stimulate much thinking directed toward the electrical transmission of scenes involving motion.

It was in 1873 that a British telegraph operator named May discovered that the chemical element selenium had the curious property of responding to light by changing its electrical resistance. This discovery was put before the engineering public by Willoughby Smith. Almost immediately thereafter, suggestions as to how it might be possible to "see by electricity" began to crop up thick and fast.

The first electric television system was proposed only two years later, in 1875, by George R. Carey of Boston, Mass. This system was in many ways analogous to the human eye. Carey planned to build a transmitter comprising a mosaic of light-sensitive selenium cells and a receiver consisting of a similar bank or mosaic of electric lights. It is worth while to examine the principle of such a system, for, so far as I have been able to find, it offers the earliest plan that would transmit to a distant point not merely the form of a visible object, but also its motion.

One way in which such a system might operate is illustrated in Figs. 1 and 2. Figure 1 shows an elementary circuit that would meet Carey's requirements. The transmitter is shown at the left and the receiver at the right. If the selenium cell at the transmitter is in darkness, its electrical resistance is very high and the current from battery B_1 flowing through the line wire and returning through the ground connections E_2 and E_1 is insufficient to operate the relay at the receiver. Consequently the conditions are as illustrated in Fig. 1, and the lamp at the receiver is not turned on. Thus we have both transmitter and receiver in the dark or "black" situation. But if the selenium cell at the transmitter is illuminated by a bright light, its resistance falls, the current from B_1 increases and the relay at the receiver operates to close its contacts and to light the receiver lamp with current from battery B_2. This represents the lighted or "white" situation. It is a very elementary type of television, but an observer at the re-

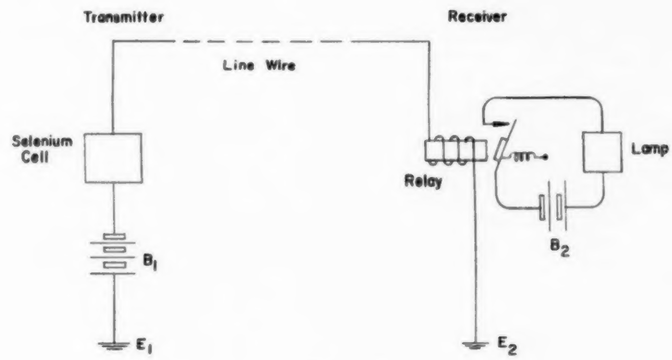


Figure 1

Presented on May 7, 1954, at the Society's Convention at Washington, D.C., by John V. L. Hogan, President, Hogan Laboratories, Inc., 155 Perry St., New York 14.
(This paper was received on May 21, 1954.)

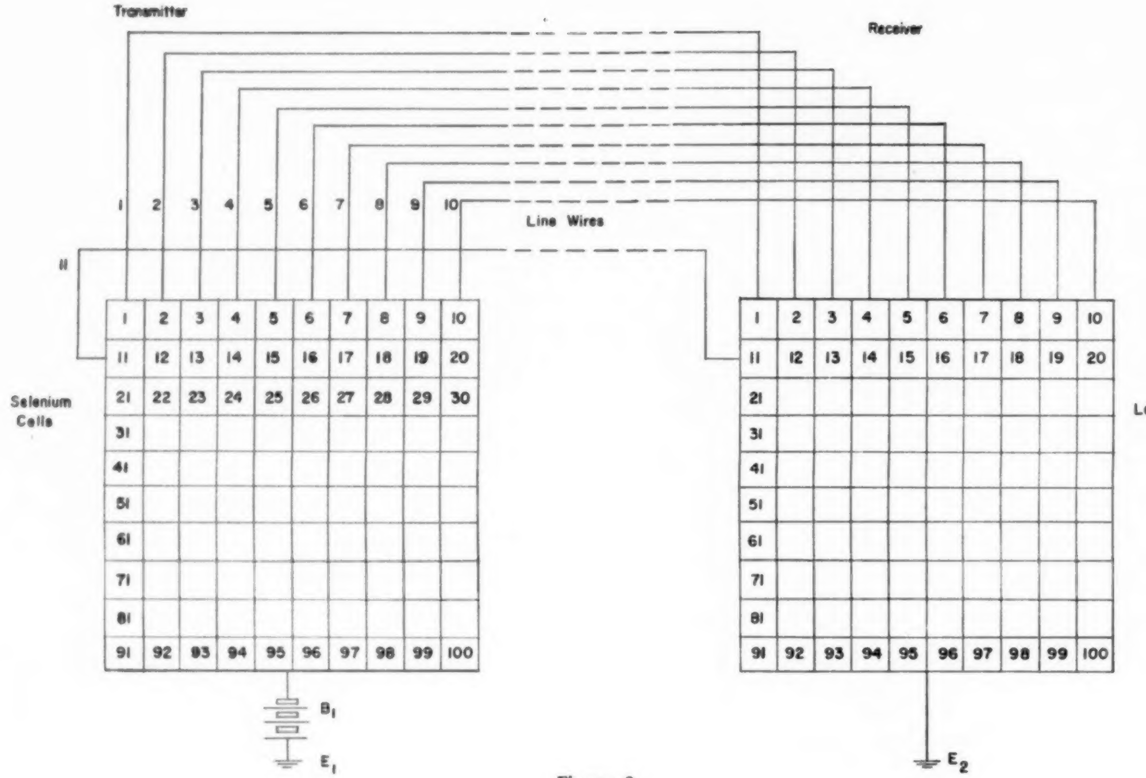


Figure 2

ceiver would know whether or not the selenium cell at the distant transmitter was illuminated. That information he could not have without the help of a system such as is shown in Fig. 1.

Carey proposed to send, from a transmitter to a distant point, much more information than the equipment shown in Fig. 1 could deliver. Figure 2 shows how he planned to accomplish that result.

Imagine the sending mechanism to consist of 100 light-sensitive cells, arranged in 10 rows of 10 cells each. The receiver comprises 100 small electric lights, also arranged in a square with 10 lights on a side. Cell 1, at the upper left corner of the sending mosaic will be connected by wire 1 with light 1, at the corresponding upper-left corner of the receiving mosaic. Cell 2 of the sender will be similarly connected by wire 2 to control light 2 at the receiver. Each of the remaining 98 cells will be connected by a separate wire to that one of the remaining 98 receiver lights which corresponds with its position in the bank. Thus 100 wires must be run from sender to receiver, plus a wire or ground common return circuit, such as from E_2 to E_1, and there must be connected into the system an on-off relay for each lamp together with the required sources of electrical power. In Fig. 2, I have omitted the relays and the battery B_2 for lighting the receiver lamps. Except for the 100-wire cable and the 100 relays, the system is not very complicated.

But how does it work? Well, if the sending mosaic is in darkness, all the lamps at the receiver will be turned off, and the screen will be dark. If the sending mosaic is completely illuminated, all the receiver lamps will be turned on and the whole screen area will be brightly lighted. In either of these simple cases the receiver gives a true picture of what the sending mosaic sees, that is, either no light or full light. It will also give a true picture of any object inserted between the light source and the pickup mosaic at the sender, within the limits of definition imposed by our assumption that the entire picture contains only 100 elements. Suppose that at the transmitting station we hold a rod horizontally across the middle of the mosaic, and that the thickness of that rod is such that it will shadow the two middle rows of light-sensitive cells. Light will thus be cut off from cells 51–60 and 61–70, and the corresponding lights at the receiver will go out. Thus any one looking at the receiver mosaic will see a horizontal black bar in the middle of the screen, which is a true picture of what we have shown to the transmitter. If the rod is held vertically in midscreen, cells 5–6, 15–16, 25–26 . . . 95–96 will be shadowed and the corresponding lights at the receiver will be extinguished. Thus an observer would see a centrally located vertical black bar, which again is a true picture of what was presented to the transmitter. It is not hard to appreciate that this crude system has the capacity of presenting at a distance, by electrical means, a visual image of the form of any object shown to the transmitter. If one desires to transmit pictures of more complicated subjects than rods, rectangles, alphabetical characters and so forth, it is only necessary to increase the resolving power of the system by adding light-sensitive cells at the pickup, together with corresponding wire-lines, relays and receiver-lights.

Perhaps I should insert here a word of warning as to this apparently simple way of increasing resolution by adding elements. We have been considering a 10×10 system, having 100 picture elements. The human eye uses a mosaic having millions of elements, so that a Carey television system which would convey as much visual information as the eye delivers to the brain would be many thousand times as complex as that shown in Fig. 2.

This multichannel television system is also capable of transmitting moving images, within the technical limitations of resolution and speed which are inherent in the equipment available at any particular date. It is not hard to see how motion can be reproduced at a distant point. Let us again imagine

the fully illuminated transmitting mosaic and, therefore, the fully lighted receiving screen. Let us take the same rod, held horizontally above the transmitter cell-bank. Let us move the rod downward, so that first its shadow blacks out cells 1–10 and (at the receiver) lamps 1–10. Moving the rod a little further downward blacks out cells and lamps 11–20 also, and the receiving observer sees the full-width image of the rod at the top of his screen. As we continue to move the horizontal rod downward, the shadow leaves cells 1–10 and covers cells 21–30. So, at the receiver, the black band has moved down one step. This continues row by row until the rod has moved so far down that it no longer shadows the lowest row of cells (91–100). If the speed of downward movement of the rod does not overtax the frequency response of the light-sensitive cells at the transmitter, and of the relays and the lights available for the receiver, a distant picture showing the form and movement of the original scene will be created. That is television.

But of course it is television of a very crude type, and of little practical value. We may doubt the possibility of finding selenium cells that would turn lamps off or on, and we may point out that the selenium cell is so sluggish in operation that only very slow motion could be picked up and transmitted to the receiver. The basic defect of the system, however, is that a separate communication channel is required for each picture element to be transmitted. In the example that we have considered, the picture was divided into 100 elements, which would suffice to handle only the simplest images. Yet 100 wire circuits were required. To pick up and reproduce scenes having sufficient detail to tell even a simple story would call for a mosaic having at least 50 cells on a side, or a total of 2500. Such a system would require at least 2500 individual circuits from sender to receiver, and yet would convey very little pictorial information as judged by today's standards. When Shefford Bidwell much later considered Carey's simultaneous system, about 1908, he assumed that 90,000 circuits would be necessary to handle an adequate picture. I do not need to emphasize the impracticability of providing so many individual circuits from the transmitter to each receiver.

The scientists of the 1880 decade appear to have recognized the necessity of finding some way to obviate the need for using a separate channel to represent each picture element. Bain and Bakewell, nearly forty years earlier, had introduced the scanning idea of looking at a picture point by point and printing a copy of it, point by point, at a distant receiver. Faraday, even earlier, had indicated that if a series of time-spaced progressive still pictures could be rapidly

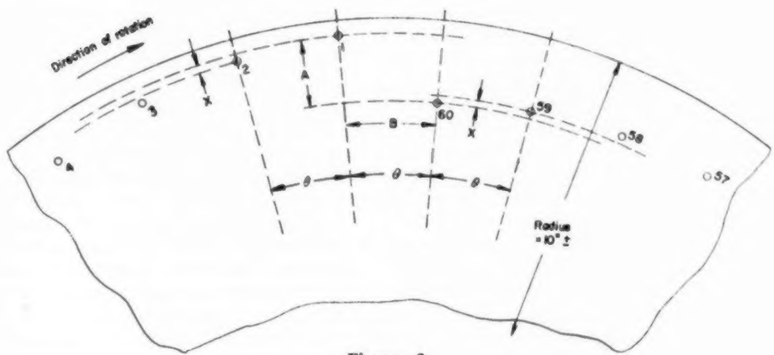


Figure 3

presented to the eye of a human observer the series of still pictures would be blended together because of the eye's "persistence of vision," and a realistic illusion of motion would result. If these two principles could be combined, so that ten or more completely scanned pictures could be transmitted per second, over a single channel, and could be displayed by a receiver, the multichannels of the simultaneous system would no longer be required. Carey later proposed the idea of moving the transmitting selenium cell in a spiral path, so examining the original image from point to point, but apparently he had in mind only a receiver that would print a simple picture on paper. Thus his concept seems to have been more nearly related to what we now call facsimile than to television. The same is true of the linear-scanning system constructed by Bidwell in 1881.

Looking back from today, it appears that Paul Nipkow was the first man to realize that television could be accomplished over a single channel by optically scanning the original scene, point by point, and fast enough to take advantage of human persistence of vision. About 1884 Nipkow explained that an image could be progressively scanned, point by point and line by line, if it were projected upon or viewed through the outer area of a large rotating disk having a number of small holes in spiral arrangement. Because the principles suggested by Nipkow were found useful in the first practical television operations and because his idea of progressive linear optical scanning is the basis of today's television, we should examine his 1884 proposal in some detail.

Figure 3 shows a portion of a scanning disk such as Nipkow described. The area to be scanned has the vertical dimension A and the horizontal dimension B. If we assume the conventional motion-picture aspect ratio of 4:3, A may be $\frac{3}{4}$ in. and B 1 in. Figure 3 shows the first and the last five holes in the disk, the holes being marked 1 to 5 on the left and 56 to 60 on the right. Since there are 60 of these holes equally spaced about the 360° comprising the circumference of the disk, the angle θ must be 1/60 of 360°, or 6°. The radial center-to-center spacing of successive holes, indicated as X, must be 1/60 of $\frac{3}{4}$ in. (dimension A), or 0.0125 in. The diameter of each hole may be something over this figure, perhaps 1/50 of an inch. To get 60 holes one inch apart around the outer portion of the disk, it must have been a circumference of something over 60 in. or a diameter of about 20 in. Finally, the disk must be rotated at a speed that will scan the picture area at the rate desired. If the image is to be completely scanned in 1/20 sec, the disk must revolve at 1200 rpm.

Now let us see how such a scanning disk may be used in a television transmitter. Nipkow planned to project the scene upon the area A by B shown in Fig. 3. On the other side of the disk there was to be a selenium cell, the electrical output of that cell being delivered to the receiver over a single circuit. That cell had to look at each element of the picture to be transmitted and to translate its light value into a proportional current. As hole number one swept across the top line of the scene, the amount of light passing through the hole and, therefore, the electrical output of the selenium cell varied in accordance with the picture density, from element to element. When the scanning of the first line was completed, the second hole of the disk began to pass across the image and to scan the second line, a little below the first. Thus successive lines from the first (at the top) to the last (at the bottom) were scanned, and the selenium cell passed a series of current values corresponding to the density of all of the elements in the picture area, one after another.

This process of scanning successive points of the picture, one at a time and one after another, is quite different from the operation of the simultaneous mosaic system that I first described. The simultaneous system required a separate communication channel or wire, from sender to receiver, for each picture element. The scanning system requires only a single connecting channel, be-

cause the signals representing elemental picture brilliance are transmitted over that channel in a time series, one after another. But its use puts a heavy burden on the equipment in terms of frequency response to light variations, because, if motion is to be shown by relying upon persistence of vision, varying current corresponding to all of the picture elements of the image must be transmitted in less than 1/10 of a second.

How did Nipkow propose to make visible his single-channel transmission of a changing secene, at a distant receiving location? He showed that all one needed was a light source whose brilliance could be controlled by the arriving signals, plus a viewing disk which was substantially a duplicate of the scanning disk used at the transmitter, plus some way of keeping the sending disk and the receiving disk revolving at exactly the same speed and in the same phase. The light source at the receiver was to illuminate the picture area A × B on one side of the receiving disk, and the viewer was to look at the light source through the holes in the disk. Thus he would see only one element of the scene at a time. If the sending and receiving disks were rotated at the same speed and in the same phase, the particular picture element seen by the receiving observer at any particular instant would have the same position in the picture field as the element being projected upon the transmitter's selenium cell at the same instant. If a picture element being scanned at the transmitter was bright or brilliantly lighted, the selenium cell would let through enough current to light the lamp at the receiver, and the observer would see a pinpoint of light through the hole in the receiving disk at the appropriate position in the picture field. Similarly, if the element being scanned was dark, the selenium cell would not pass enough current to light the receiving lamp, and that particular spot of the area being viewed at the receiver would appear black to the observer. Thus the entire picture was to be analyzed point by point and line by line at the transmitter and to be simultaneously synthesized, point by point and line by line at the receiver. All of the picture elements in the picture were to be successively scanned so rapidly that the human eye would retain its impression of the brilliance of the first element, in the upper lefthand corner of the scene, until the brightness of the last element, in the lower righthand corner, had been transmitted. Thus the observer would appear to see a complete picture although he was actually viewing only one element at a time.

Carey and Nipkow were not the only inventors to propose electrical television systems in what we may call the speculative period from say 1875 to 1890. Senlecq, in France, Ayrton, Perry and Bidwell in England, and Bell in the United States were among those who suggested various types of equipment that might have been used for television. Senlecq's 1880 scheme was of particular interest, for his transmitter comprised a bank of small selenium cells, like Carey's, and his receiver a similar bank of incandescing platinum wires. However, he did not plan to connect each cell to its corresponding lamp by means of a separate line wire. Instead, he advanced the idea of using synchronous distributors at sender and receiver to connect a single line wire successively to each selenium cell and to the corresponding lamp. Here we have a scanning system of an electrical, rather than an optical, nature.

None of these workers in the "speculative period" produced and demonstrated a working television system. So far as I know, nobody developed hardware that could effectively meet the practical requirements of these early television systems until the twentieth century was well on its way. But all of us should remember that many, if not most, of the basic principles of today's television had been thought of some sixty to eighty years ago. That early thinking was highly creditable and constructive, and vastly more important than mere intellectual exercise.

Why did not these inventors produce working television systems? Well, what would we do in television today if we were limited to the slow and weak response of the selenium cell, as compared to the rapid action and high sensitiveness of the modern photocell? What would we do if we had no vacuum-tube amplifier? What would we do if we had no light source whose brilliance could be easily and rapidly controlled by varying the applied voltage? Before 1900 not even one of those essential elements was available. But soon thereafter they began to appear, at first in undeveloped and unsatisfactory but nevertheless promising forms, and in the first two decades of the twentieth century all of them became practical. By 1913 Elster and Geitel had produced the fast and sensitive potassium hydride photoelectric cell, and de Forest had succeeded in making the grid audion work as an audio-frequency amplifier. Thus two essential tools for practical television came on the horizon. The third need was a light source which could be rapidly controlled in brilliance by a varying electric current. A number of magnetic shutter or light-valve schemes were available, at least in theory, but the most practical solution seems to have been provided by D. McFarlan Moore, then of the General Electric Co. About 1917 he produced a negative-glow neon lamp which could be electrically modulated in brilliance. Working with Jenkins in the following years, and using the de Forest amplifier, he developed this glow lamp into an operative light source for a television receiver.

It was not until 1925, however, that these new tools were well enough understood and sufficiently available to end the hiatus of some thirty years that separated the speculative period ending about 1890 from what might be called the experimental period beginning about 1920.

1925 seems to have been the "magic year" for the first electrical transmissions of moving images from one place to another. Jenkins in the United States and Baird in the United Kingdom are both credited with accomplishing such image transmission within the first half of that year. Historians do not agree as to which of these experimenters should be recognized as having been in the lead. The available records suggest that the credit should be more or less equally divided between them, for they seem to have been running a neck-and-neck race for a number of years. Sometimes one was ahead and sometimes the other but together they did a great deal to bring television before the public. Each of them showed considerable ingenuity in applying the newly available scientific tools to the practical application of the principles that had long before been suggested by Nipkow and his contemporaries. Both Baird and Jenkins adopted the Nipkow single-channel time sequential or scanning system rather than the Carey multiple-channel simultaneous or mosaic system. The validity of their choice has been demonstrated by the fact that all television from 1925 to the present day has followed their lead in that respect. Many of the things that Baird and Jenkins accomplished should be recognized as new and useful, and, therefore, as "inventions." In any event, 1925 saw television as a fact and not merely as a dream. The experimental period was about five years old.

Once it had been proved that the early proposals for electrically seeing at a distance could really be implemented (or physically "reduced to practice") by using the newly available electronic tools, television entered an unbroken phase of application and improvement. From 1925 to the present time there has been no hiatus comparable to that which occurred between 1890 and 1920.

That is undoubtedly because after 1920 the experimenters and scientists had enough tools available to assure them that acceptable television could be developed. But what is acceptable television?

Perhaps the best way to answer that question is to review what actually happened.

In 1927, two years after the first showings by Baird and Jenkins, the Bell System demonstrated the results of a

television research that must have been begun long before. Bell System engineers then showed how the Nipkow disk, the Elster and Geitel photocell, the de Forest amplifier and the Moore glow lamp could be used to transmit scenes electrically, either by wire or by radio, over distances of many miles. To attain this result they added new products of their own ingenuity and "know how" to what had been suggested by the pioneer thinkers and doers. The Bell accomplishments, for which Dr. Ives was largely responsible, marked a milestone in the progress of television and probably did more to show its practical utility than had any of the prior experiments. The picture was scanned in 50 horizontal lines at the rate of 18 frames/sec, which was adequate for the reproduction of easily recognizable full-face portraits or of relatively simple views. The halftone or photographic-transmission was good, so that the system was not limited to black-and-white silhouettes, and provision was made for the delivery of sound along with the picture. Thus an observer in New York could talk by telephone with another person in Washington and, during the entire conversation, could see a televised image of the distant speaker. For such "person to person" television communication the received image on the Nipkow disk was viewed through a lens, so that the picture appeared to be about 2 × 2½ in. in size.

To enable a number of viewers to see the same received picture, the Bell engineers devised a special neon glow lamp made up of a gas-filled tube bent back and forth to cover an area of some five square feet. The arriving picture currents were fed to external electrodes on this tube by way of a rotary distributor which was driven in synchronism with the distant scanning disk. Thus elemental areas of the display system were successively lighted to an intensity corresponding to the brightness of the similarly placed element in the original scene. A complete field was scanned in about 1/18 sec, and so the observers could see the outlines, shading and motion of the televised view.

The next year, 1928, the General Electric Co., from Station WGY in Schenectady, began the regular radio broadcasting of televised pictures accompanied by sound. This work, under the guidance of Dr. Alexanderson, led to the showing of large-screen projected television pictures. The first broadcasts were put on the air three times a week, and used 24-line scanning which limited the pictorial content to about one-quarter of that which characterized the Bell System demonstrations. In July of the same year, 1928, Jenkins began television broadcasting from his experimental radio station W3XK near Washington, D.C. His pictures were scanned at 48 lines/frame and 15 frames/sec. Most of his subjects were on film, so that he was able to replace the Nipkow disk having spirally arranged holes by a scanning disk in which the holes or lenses were placed circumferentially at a single radial distance from the driving shaft. Fast or horizontal line scanning was accomplished by the sweeping of these apertures across the film, but the line-by-line advance or slow scanning in the vertical dimension was had by continuously moving the film lengthwise.

The increasing interest in television was shown by the establishment of additional picture-broadcasting stations in the next few years. In 1929 Baird, cooperating with the British Broadcasting Company, began to send out pictures scanned at 30 lines per frame and 12½ frames/sec. That same year several new stations went on the air in the United States, including W2XBS of the National Broadcasting Company and my own W2XR. We both used a somewhat higher scanning standard, namely 60 lines/frame and 20 frames/sec.

If one must choose a date for the end of the "the early days of television" it might as well be 1930. By then the possibilities of mechanically driven optical scanning systems had been quite thoroughly explored, and it had become evident that the apparently insatiable demand for the electrical transmission of more and more picture content could be appeased, if not satisfied, only by making use of the cathode-ray tube for fast scanning. The change to today's all-electronic television did not come at a single date. There was a large overlapping period in which the possibilities of cathode-ray tubes were being explored and the limits of mechano-optical television systems were being determined. In fact, the two concepts were proposed for use together in various ways. Rosing in 1907, suggested a mirror-drum transmitter to be used with a cathode-ray tube receiver. The Radio Corporation of America in 1932 used a refined mechanical scanner to feed television signals to a cathode-ray tube display. My own Laboratory worked out a television receiver in which a cathode-ray tube was used for the required fast scanning but the area or slow-scanning presentation was provided by rotating concave mirrors.

In closing, let me apologize for having omitted discussion of the early progress in connection with the difficulties involved in providing synchronization between sender and receiver. Briefly, the synchronizing problem was attacked by every means from clock work to electronic frequency standards, but was solved as a practical matter by using the same 60-cycle power source to drive the motors at the sender and at the receiver. The Bell Telephone Laboratories, in their 1927 work, used a much more elegant but equally practical system.

I have now carried you, at least in thought, from 1875 to 1930. In 1875 there was suggested a television system that could be made to work. In 1930 there were television pictures on the air, available to any one who had a suitable receiver. In another paper Mr. Jensen will tell you how these broadcast pictures have been improved in content and in quality over the past 25 years.

The Evolution of Modern Television

By A. G. JENSEN

This paper first describes the gradual transition from mechanical television to the present all-electronic television. It gives a brief account of the major developments leading to the present types of pickup and reproducing equipment, and describes the growth of network facilities which has made possible the present wide distribution of television programming in the United States.

IN THIS PAPER modern television implies the type of television now used for commercial broadcasting in the United States and elsewhere. This is an all-electronic type of television which utilizes electronic pickup tubes of one form or another at the transmitting end and cathode-ray tubes for displaying the picture at the receiving end. Such a system is in contrast to earlier experimental television systems using mechanical-optical scanning means both at the transmitting end and at the receiving end. These earlier types of systems have been described by J. V. L. Hogan in a companion paper.[1]

It is obvious that the transition from the earlier mechanical systems to our present electronic systems was a very gradual one. Roughly speaking, we may say that the period before 1930 was that of the all-mechanical television system, the period from 1930 to 1940 was the period of the partially electronic system, and the period from 1940 on was that of the all-electronic television system. It was natural that the comparatively simple cathode-ray tube at the receiving end should be perfected sooner than the more complicated pickup tubes at the transmitting end, and, up to the middle thirties, the systems experimented with were mostly of a type that utilized mechanical-optical scanning means at the transmitting end but used a cathode-ray tube as the display device at the receiving end. From 1935 to 1940 the mechanical scanning means at the transmitting end were gradually superseded by steadily improved electronic camera tubes, but it is interesting to note that even as late as 1939 and 1940 some of the best television pictures were produced with transmitting equipment using Nipkow discs. This was the case here in the United States and also in England, Germany and Holland.[2] In an art which has developed as rapidly and in as revolutionary a way as television, it is rather extraordinary that this should be the case, considering that the Nipkow disc was invented sixty years earlier.

Early Inventions

While the experimental development of electronic pickup and reproducing equipment did not really get started until around 1930, it is interesting to note that the conception of such devices is quite a bit older.

The earliest experiments with the use of a cathode-ray tube as a television receiver were probably those of Prof. Max Dieckmann in Germany. One is described in a German patent application dated September 12, 1906, called "A Method for the Transmission of Written Material and Line Drawings by Means of Cathode Ray Tubes."[3] A description of these early experiments and several pictures of the equipment can be found in a recent article in a German magazine giving the history of television in Germany up to 1945.[4] Figure 1 is reproduced from this magazine and shows Dieckmann's experimental setup, consisting of a cathode-ray tube receiver adjacent to a Nipkow-type scanner used as a transmitter. The cathode-ray tube used deflection modulation and magnetic deflection for both directions of scanning. Due to a particular design of the Nipkow disc, the signals obtained from the transmitter were of a facsimile nature, indicating either black or white, but no half-tones. For this reason it has been argued that Dieckmann's experiments were not true television, but rather facsimile transmission. The fact remains, however, that the cathode-ray tube receiver by itself did not have this limitation and would have been able to reproduce half-tones as well as any other cathode-ray tube of those early days. The equipment shown in Fig. 1 is still in existence and is housed in the Deutsches Museum.

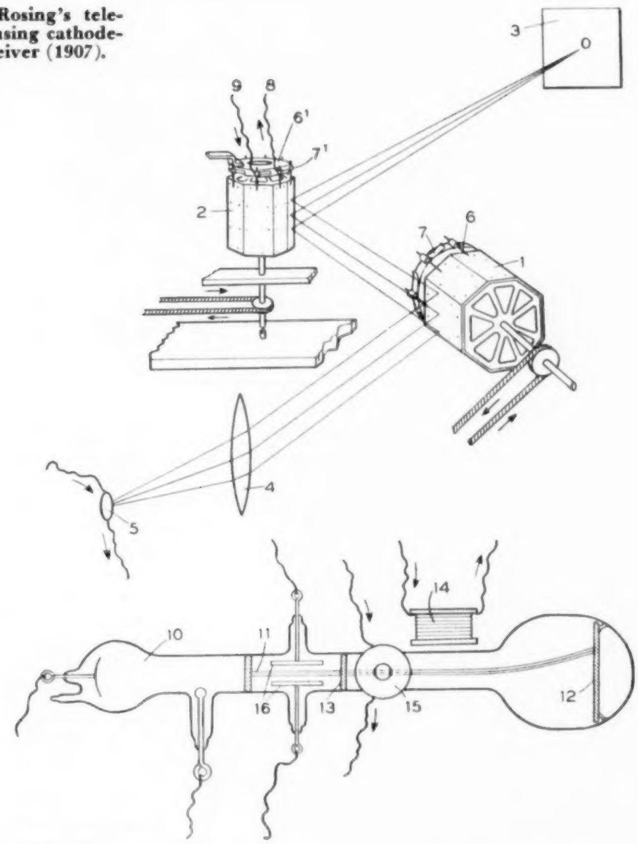
Another early description of a cathode-ray tube used as a television receiver is due to Prof. Boris Rosing, who was a lecturer at the Technological Institute at St. Petersburg in Russia. Rosing called his invention the "electric eye," and it is described in two British patents of 1907 and 1911[5] and also in a couple of articles in the *Scientific American* of 1911.[6] Figure 2 is a reproduction of a drawing in Rosing's 1907 patent. The transmitter images the object (3) in the plane of the photosensitive cell (5), and by means of two rotating mirror drums this image is moved vertically and horizontally across the photosensitive element, which in this manner scans the entire picture. The receiver is a cathode-ray tube with a fluorescent screen (12), a pair of magnetic deflecting coils (14 and 15), and a

Fig. 1. Earliest experimental model of German cathode-ray tube television receiver (Dieckmann, 1906).

Presented on May 7, 1954, at the Society's Convention at Washington, D.C., by A. G. Jensen, Bell Telephone Laboratories, Inc., Murray Hill, N.J.
(This paper was received on September 15, 1954.)

pair of modulating plates (16). The saw-tooth deflecting current for the coils is obtained from rheostats mounted on the mirror drums and with contacts so arranged that the current from the rheostat varies linearly with the rotation o the drums. As the signal from the photosensitive element (5) on the transmitter is impressed on the modulating plates (16), it causes the electron beam to be deflected away from a hole in a diaphragm (13), thereby changing the strength of the beam impinging on the fluorescent screen. It must be remembered that cathode-ray tubes, or Braun tubes as they were called in those days, did not then have very well focused beams, and it is doubtful whether a very satisfactory picture could be obtained with tubes of that sort. But it is interesting to note that Rosing employed the principle of deflection modulation of the electron beam, a principle which was later utilized very successfully by Dr. C. J. Davisson in a cathode-ray tube built in the late 1930's. The patent descriptions of this system indicate that Rosing did some experimental work, but there is no record of any successful demonstrations.

Fig. 2. Boris Rosing's television system using cathode-ray tube receiver (1907).



A still more startling invention was made by A. A. Campbell Swinton in 1911. Swinton was an outstanding British consulting engineer, who was born in 1863 and died in 1930. He was mainly connected with the design and development of electric lighting and electric traction in England, and was also associated with Sir Charles Parsons in the development of the steam turbine. However, apart from his business, he was also keenly interested in the newer developments in physics and electronics, particularly in the fields of x-rays and television. He was a Fellow of the Royal Society, and made many experiments both in the field of x-rays and in the field of radio. Swinton's invention was triggered by a letter written by Shelford Bidwell to *Nature* in 1908.[7] Bidwell had been interested in experiments in television since 1880, and he wrote his letter to comment on an earlier letter by Armengaud of Paris, in which the author stated that he "firmly believes that within a year, as a consequence of the advance already made by his apparatus, we shall be watching one another across distances hundreds of miles apart."

Armengaud's television system was purely mechanical, and Bidwell takes issue with him with respect to the accuracy of synchronization obtainable by such a system. Bidwell assumes a picture 2 in. square and estimates that, to equal the definition of a good photograph, such a picture would require 160,000 elements. With 10 pictures per second this would mean 1.6 million synchronizing operations per second which, according to Bidwell, is "wildly impracticable."

Instead of such a system, Bidwell suggests that one should consider a system based on the operation of the human eye, that is, a system with a large number of individual cells connected by separate wires. He estimates that for 90,000 picture elements one would require at the transmitting end a screen consisting of selenium cells and occupying a space 8 ft square. This screen would be illuminated by the object by means of a projection lens with a 3-ft aperture. He further estimates that the receiver would occupy a space of 4000 cu ft, although he does not specify what the actual receiving element would be. The 90,000-conductor cable is estimated to have a diameter of 8 to 10 in. and to cost about 1¼ million pounds for 100 mi. (It is interesting to note that this cost is at least an order of magnitude greater than the cost of present-day coaxial cables, and this is in spite of the fact that Bidwell's system would require less than one megacycle for its transmission, and that the pound of 1908 was worth a good deal more than it is today.)

In reply to Bidwell's letter, Swinton wrote as follows[8]:

"Distant Electric Vision

"Referring to Mr. Shelford Bidwell's illuminating communication on this subject published in NATURE of June 4, may I point out that though, as stated by Mr. Bidwell, it is wildly impracticable to effect even 160,000 synchronized operations per second* by ordinary mechanical means, this part of the problem of obtaining distant electric vision can probably be solved by the employment of two beams of kathode rays (one at the transmitting and one at the receiving station) synchronously deflected by the varying fields of two electromagnets placed at right angles to one another and energised by two alternating electric currents of widely different frequencies, so that the moving extremities of the two beams are caused to sweep synchronously over the whole of the required surfaces within the one-tenth of a second necessary to take advantage of visual persistence.

"Indeed, so far as the receiving apparatus is concerned, the moving kathode beam has only to be arranged to impinge on a sufficiently sensitive fluorescent screen, and given suitable variations in its intensity, to obtain the desired result.

"The real difficulties lie in devising an efficient transmitter which, under the influence of light and shade, shall sufficiently vary the transmitted electric current so as to produce the necessary alterations in the intensity of the kathode beam of the receiver, and further in making this transmitter sufficiently rapid in its action to respond to the 160,000 variations per second that are necessary as a minimum.

"Possibly no electric phenomenon at present known will provide what is required in this respect, but should something

* Apparently Swinton lost track of the fact that Bidwell suggested 10 pictures per second, each with 160,000 elements. The figure therefore should be 1,600,000 operations per second.

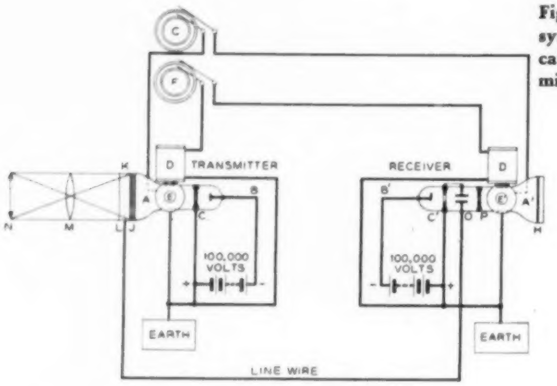


Fig. 3. Campbell Swinton's system of television using cathode-ray tubes as transmitter and receiver (1911).

suitable be discovered, distant electric vision will, I think, come within the region of possibility."

The foresight expressed in this letter is truly remarkable when one realizes that it was written in the early infancy of radio transmission, and at a time when the electron tube amplifier had not yet been invented and when photoelectric equipment was still very inefficient and primitive.

Three years later, Swinton elaborated on his suggestion in a presidential address to the members of the Röntgen Society in November 1911.[9] In this address he gave a detailed description of his proposal and illustrated it with a diagram which is reproduced in Fig. 3. The figure shows his conception of a camera tube involving the use of a mosaic screen of photoelectric elements which was scanned by an electron beam. The signal from the camera tube is impressed upon a pair of deflection plates in a cathode-ray tube receiver. Just as in Rosing's suggestion, Swinton makes use of deflection modulation in the receiving tube. Magnetic coils are used both at the transmitter and at the receiver for deflecting the electron beams, and synchronism is insured by using a common alternating-current supply for the two ends.

Swinton apparently never built a complete model of his system but he remained interested in it and, up to the time of his death, talks by him indicated that he had made several experiments to construct a satisfactory mosaic for the transmitter tube. Thus in 1924 he gave a lecture before the Radio Society of Great Britain entitled "The Possibilities of Television."[10] In this lecture he dealt in detail with his earlier suggestion in 1911 and discussed his latest thoughts on the best design of the mosaic plate in the transmitting tube. He also pointed out that the advent of the electronic amplifier and of radio communication had greatly enhanced the possibilities of successful transmission of television signals. The lecture was followed by a lively discussion and, in his answer to a questioner, Swinton concluded as follows:

> "...I wish to say that I agree entirely with Mr. Atkinson that the real difficulty in regard to this subject is that it is probably scarcely worth anybody's while to pursue it. That is what I have felt all along myself. I think you would have to spend some years in hard work, and then would the result be worth anything financially? If we could only get one of the big research laboratories, like that of the G.E.C. or of the Western Electric Company—one of those people who have large skilled staffs and any amount of money to engage on the business—I believe they would solve a thing like this in six months and make a reasonable job of it."

Here again Swinton shows an uncanny ability to foresee the future of television. It was indeed by the efforts of the large companies that modern-day high-definition television was finally developed, although it took a good deal longer than the six months estimated by him. It is to be regretted that he died too soon to witness the practical development of his ideas.

Cathode-Ray Tube Receiver

The experiments described above all dealt with the earlier types of Braun tubes which were only partially evacuated. They were generally filled with argon or some other rare gas with a pressure of 10^{-2} to 10^{-4}mm of mercury, and it was not possible in these tubes to obtain a very sharp focus. As the art progressed, however, the tubes were gradually improved, and by the middle 1920's several experimenters were working with such tubes, both here in the United States and abroad. One of the first experimenters in this field in the United States was Vladimir K. Zworykin, who came to this country in 1918 and did his early work with the Westinghouse Research Laboratories. In the years around 1910 he had been a student under Rosing at St. Petersburg and had worked with him in the early experiments with Braun tubes as television receivers. He continued this work here in America, and his first patent application describing a complete electronic television system was issued in 1923.[11] Figure 4 shows a picture of the cathode-ray receiving tube in the abovementioned patent application. It will be noticed that the tube has a cathode (56), a modulating grid (54), an anode (57), and a fluorescent screen (60). No mention is made about the vacuum in the tube, but in a 1925 patent application a somewhat similar tube is described using low-pressure argon and it may be assumed, therefore, that this first tube also was argon-filled and depended on the argon for focusing the beam. The condenser plates (58 and 59) are used for producing electrostatic horizontal deflection, while the coils (69 and 70) produce magnetic vertical deflection.

According to Zworykin, the first demonstration of an all-electronic system using such a cathode-ray tube at the receiver and an early form of camera pickup tube at the transmitter took place in 1924. However, the pictures were scarcely more than shadow pictures with rather poor definition. It was apparent to Zworykin that the biggest problem was to produce a satisfactory pickup tube

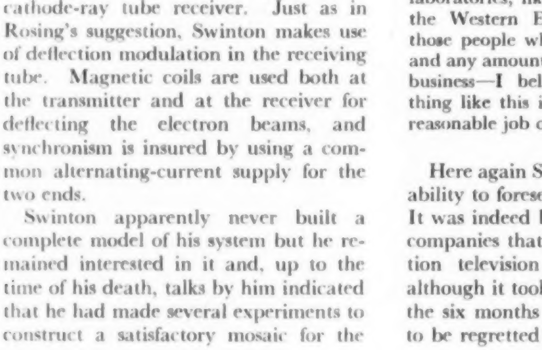


Fig. 4. Zworykin's earliest form of cathode-ray receiving tube (1923).

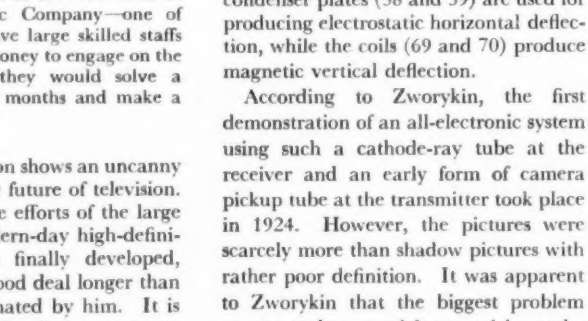


Fig. 5. Early Zworykin cathode-ray receiving tube (1933).

and, in order to achieve better results as soon as possible, he reverted for the next few years to the use of mechanical scanning means at the transmitter and concentrated on the design of better cathode-ray tubes for the receiver. The first published account of these early experiments will be found in an article in *Radio Engineering* for December 1929.[12] The article describes experiments which used a tube with a 7-in. diameter screen. It employed a simple form of electrostatic focusing, grid modulation, and both magnetic and electrostatic deflection. In this article Zworykin first coined the word "kinescope" for the receiving tube.

Around 1930 Zworykin joined the RCA Laboratories, and in the years 1931 and 1932, he and other RCA engineers constructed a complete television system utilizing a cathode-ray tube at the receiver. The transmitter still was mechanical, making use of a Nipkow disc for the scanning process, but the receiving tube had undergone a great deal of development and began to look more like present-day cathode-ray tubes.

This work was described in an article in the *Proceedings of the I.R.E.* for December 1933,[13] and Fig. 5 shows a cross-sectional picture of the cathode ray receiving tube taken from this article. Figure 6 is a diagrammatic view of the cathode and the two anodes of this tube, and it is obvious from the figure that the application of electron optics to proper focusing of the electron beam by means of electrostatic lenses was by that time quite well understood. In order to obtain such focusing the tube must have been of the same high-vacuum type as those employed in today's television receivers. The tube face was 9 in. in diameter and the tube was 19 in. long. Magnetic deflection was used in both directions, and the pictures produced had 120 lines/frame and 24 frames/sec. Several photographs of such pictures are shown in the article mentioned above.

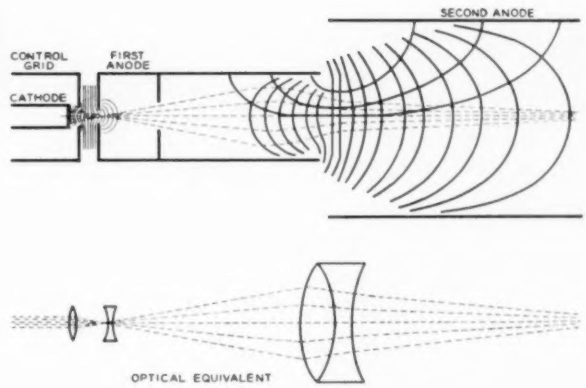


Fig. 6. Constructional details of early Zworykin cathode-ray receiving tube (1933).

Another early experimenter with cathode-ray receiving tubes in this country was Philo T. Farnsworth, who did his early experimental work in San Francisco in the late 1920's and early 1930's. He too was working with an all-electronic system using cathode-ray tube devices both at the receiving and at the transmitting ends. The transmitting tube was of a different type than that conceived by Zworykin, and will be described later on. The receiving tube, however, was quite similar to the early types of receiving tubes used by Zworykin. The early experimental work by Farnsworth is described in articles appearing in *Wireless World* and *Television News* in 1931.[14] Figure 7 from the article in *Wireless World* shows a picture of the cathode-ray receiving tube which Farnsworth called an "oscillite." A complete receiver using such a tube is shown in Fig. 8. The pictures had 200 lines/frame and 15 frames/sec, and Farnsworth stated that the bandwidth necessary for transmitting such a signal should be about 300 kc. Even in these earliest tubes, Farnsworth used magnetic deflection for both directions.

Another early experimenter with cathode-ray tubes for television was Manfred von Ardenne in Germany. His work is described in several articles in the German magazine *Fernsehen* during 1930 and 1931.[15] As will be discussed later, von Ardenne was probably the first to experiment with a cathode-ray tube as a flying-spot scanner at the transmitting end, and the experiments described in the above-mentioned article utilized this arrangement at the transmitter. Figure 9 shows a photograph of a table model receiver as taken from one of these articles, while Fig. 10 shows a photograph of a picture obtained on such a receiver. The pictures had 60 lines/frame and about 9000

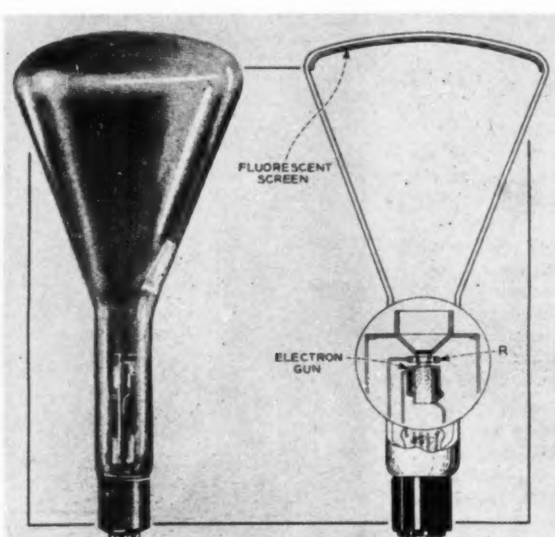


Fig. 7. Early model of Farnsworth cathode-ray receiving tube (1931).

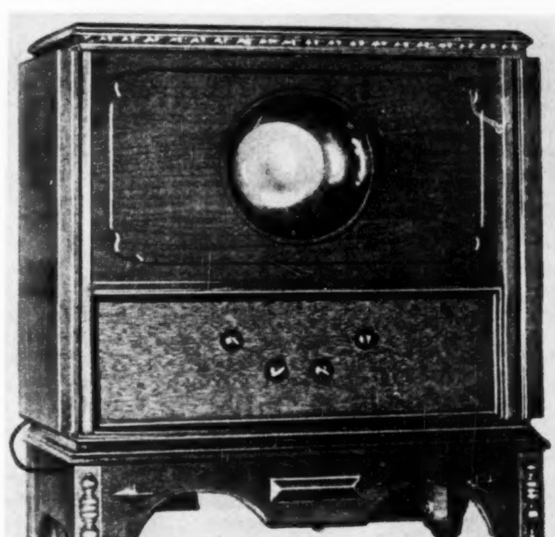


Fig. 8. Early model of American cathode-ray tube television receiver (Farnsworth, 1931).

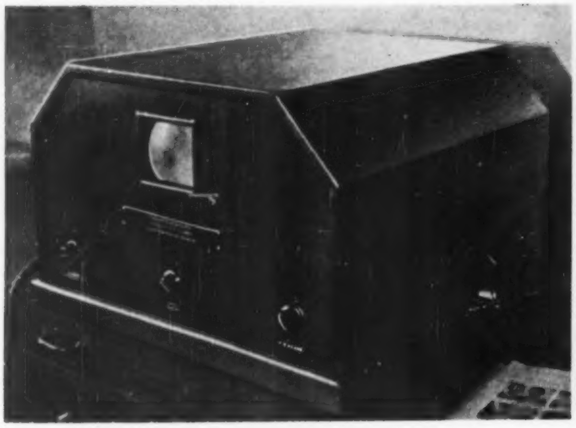


Fig. 9. Early model of German cathode-ray tube television receiver (von Ardenne, 1930).

Fig. 10. Photograph of early German cathode ray tube television picture (von Ardenne, 1931).

picture points, which would correspond to a bandwidth of about 75 kc. According to von Ardenne, this limitation in detail was entirely due to the sending arrangement and the receiving tube by itself was capable of producing pictures with about 20,000 to 30,000 picture elements/frame.

During the next twenty years, the early forms of cathode-ray receiving tubes described above were steadily being developed and improved in a number of laboratories and by a number of different organizations. Increased knowledge and application of electron optical principles made it possible to design tubes with higher and higher definition. By the middle 1930's pictures were being shown with as many as 300 lines/frame. During the 1940's pictures were shown with 500 or more lines and, at present, tubes can be made which are capable of resolving 1000 or more lines. At the same time manufacturing methods were developed and steadily improved to permit the production of larger diameter tubes. Up to 1940 very few tubes with diameters over 10 or 12 in. were used, while nowadays television receiver tubes are made with diameters as large as 30 in.

As a somewhat unusual phase of this development, it might be of interest to mention a cathode-ray receiving tube designed by C. J. Davisson of the Bell Telephone Laboratories for use in the first transmission of television signals over the coaxial cable from New York to Philadelphia in 1937.[14] Davisson designed this tube on the basis of his knowledge of electron optics, and at no stage would he depart from a design which would allow him accurately to predict the performance. This accounts for the "thin" lenses used in the different focusing systems, for the small deflection angles employed to insure sharp focus all over the screen, and for the extreme care with which the deflection-plate system was made to avoid either "pin cushion" or "barrel" distortion. It resulted in a very long tube (about 5 ft), as shown in Fig. 11, and an unusually complex assembly of precision mechanical parts, as shown by the diagrammatic representation of the tube in Fig. 12. It also resulted in an actual performance very close to the predicted performance and markedly superior to that of other television receiving tubes of the same period. It is interesting to note that Davisson in this tube reverted to the old method of deflection modulation in order to insure more complete control over the size and shape of the spot on the screen.

Cathode-Ray Tube Flying-Spot Scanner

The use of the light spot of a cathode-ray tube raster as a scanning means for scanning lantern slides or motion-picture film was first proposed by Zworykin in the 1923 patent application mentioned above.[11] Figure 13 shows the proposed arrangement in this patent application. The light from the scanning raster is made to fall on a lantern slide (78), and the light passing through the slide is focused by the lens (77) onto the photocell (76). While the optical arrangement proposed here is not altogether clear, the fundamental idea of obtaining a television signal in this manner is quite obvious.

The first experimenter to put this suggestion into practice was von Ardenne, and his experiments are described in the articles already mentioned above.[15] The general arrangement of the transmitter and receiver is shown in Fig. 14, taken from the article, and here the optical arrangement at the transmitting end is quite proper except that an additional condensing lens between the lantern slide and the photocell amplifier might have been advantageous. The frame frequency of 25 and the line frequency of 1500 would indicate that each picture consisted of 60 lines. Figure 15, also from the same article, shows an experimental setup of the cathode-ray tube used for scanning motion-picture film, and a sample of the pictures obtained was shown above in Fig. 10.

The use of such a cathode-ray tube flying-spot scanner even for live pickup was proposed by von Ardenne, as indicated by Fig. 16 from the same article. Here the scanning raster of the tube is

Fig. 11. C. J. Davisson cathode-ray receiving tube (Bell Telephone Laboratories, 1937).

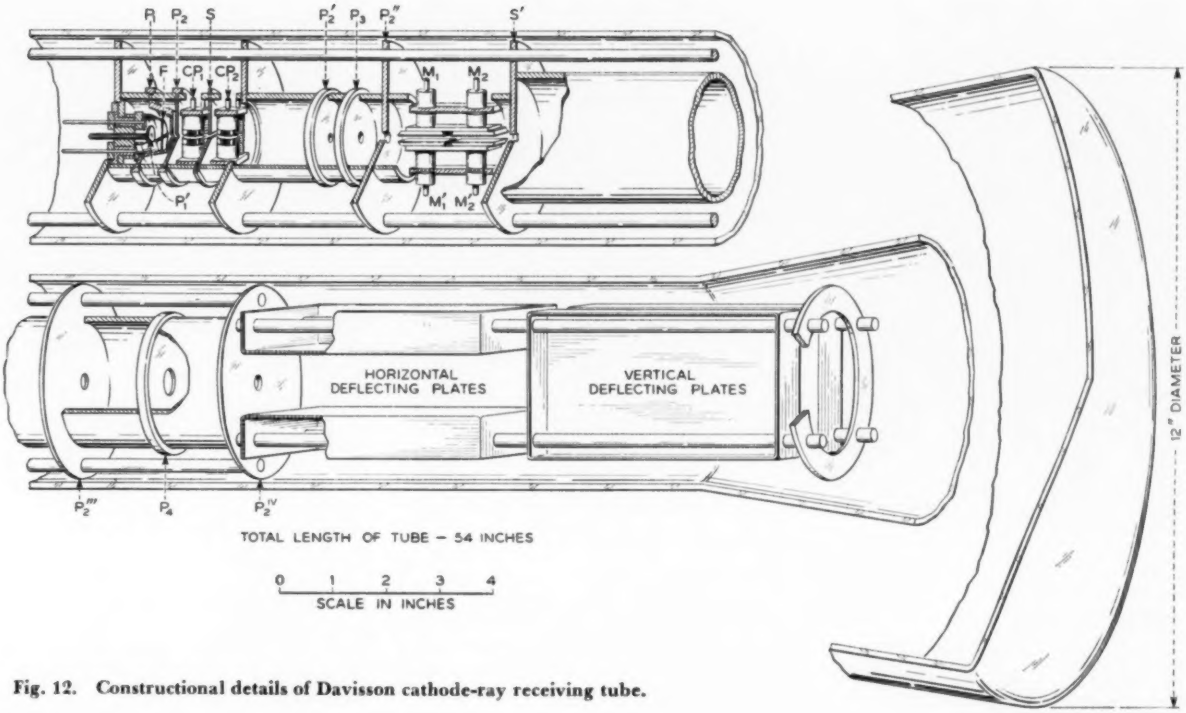


Fig. 12. Constructional details of Davisson cathode-ray receiving tube.

imaged by means of a lens in the plane of the object, in this case the head of a person. The light reflected from the object is then picked up by photocells arranged around the object, and the signals from the photocells are amplified and sent to the transmitter.

It appears that for many years following von Ardenne's experiments no further work was done with cathode-ray tubes as spot scanners. This probably was due to the fact that, as the art progressed toward pictures with higher and higher definition, the cathode-ray tube became inadequate as a spot scanner because of the comparatively slow decay in the phosphors. For receiving tubes it is necessary only that the light decay appreciably in the time between successive field scans, i.e., in 1/60th of a second, and phosphors with this order of decay time were well known even in the 1930's. For spot-scanning tubes, on the other hand, it is necessary that the light decay appreciably in the time corresponding to one picture element. Otherwise the afterglow would result in an intolerable smearing or blurring of the image. For modern high-definition television this means that the phosphor decay can be only a very small fraction of a microsecond, and phosphors of this type were not known until around 1940. One of the earliest discussions of the requirement for spot-scanning phosphors can be found in an article in a German magazine in 1939.[17] A description of one of the first high-definition lantern slide spot scanners used in this country will be found in an article in the *Proceedings of the I.R.E.* in 1946.[18] This particular spot scanner was used for scanning motion-picture film, a purpose for which a cathode-ray tube scanner is particularly well adapted. This problem will be discussed in more detail later on under Film Scanners. Since that time many types of cathode-ray tube spot scanners have been developed and are now available commercially.

Camera Tubes

Electronic camera pickup tubes may be divided into two types. One type is the instantaneous or nonstorage type tube, as exemplified by the Farnsworth dissector tube, while the other is the storage type of camera tube, as exemplified by Zworykin's iconoscope and practically all of the later types of camera tube types used today. In the following we shall discuss the development of both of these types of camera tubes.

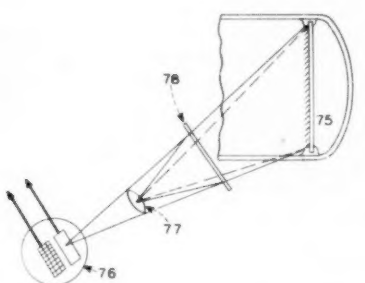


Fig. 13. Earliest picture of Zworykin's cathode-ray tube spot scanner (1923).

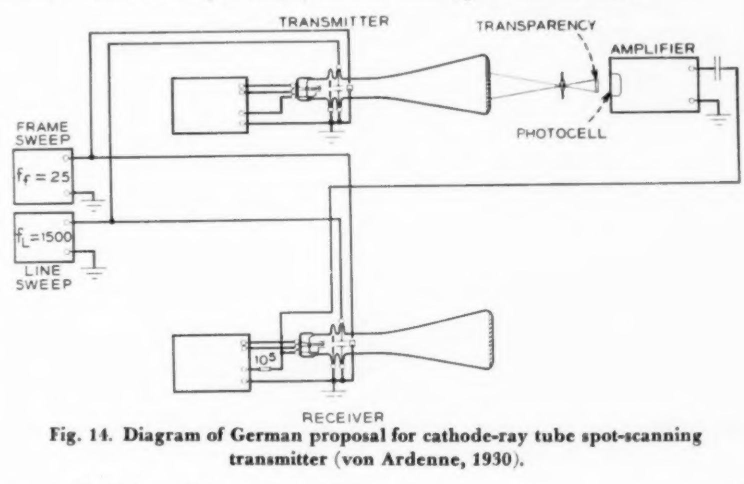


Fig. 14. Diagram of German proposal for cathode-ray tube spot-scanning transmitter (von Ardenne, 1930).

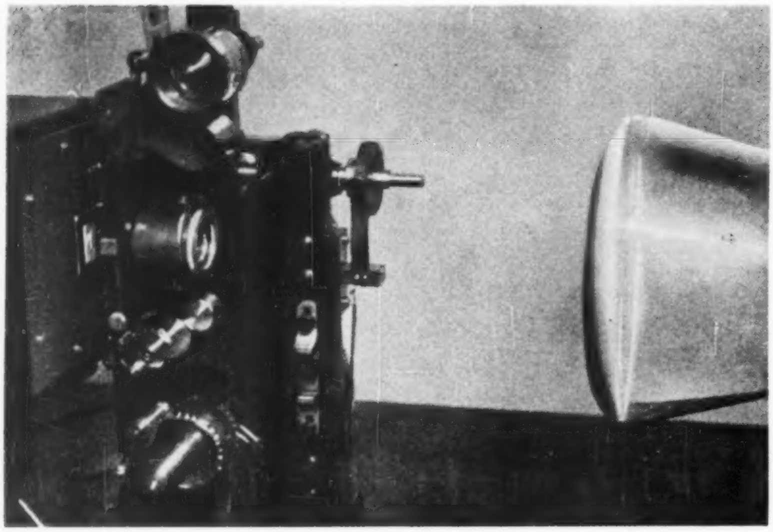


Fig. 15. Early German cathode-ray tube film scanner (von Ardenne, 1931).

A. Dissector Tube

The dissector tube was developed by Farnsworth and was first described by him in a patent application dated January 7, 1927.[19] While the fundamental principles of the tube are described in this patent application, there were still several essential improvements to be added before the tube would operate satisfactorily. These additions were incorporated in several subsequent applications, and a complete description of the method of operation of the tube was first given by Farnsworth in an article in the *Journal of the Franklin Institute* in 1934.[20]

One interesting feature of Farnsworth's earliest patent application is the fact that he does not use at the receiver a cathode-ray tube as in his later applications and as discussed above. Instead he uses a Kerr cell for controlling the intensity of a polarized light source in accordance with the received signal strength, and the light beam after leaving the Kerr cell is then deflected onto a screen by use of two galvanometer mirrors controlled by the scanning signals. This is probably one of the very few proposals, if not the only one, for a television system using electronic means at the transmitting end and mechanical scanning means at the receiving end.

Figure 17 shows a cross-sectional view of the dissector tube as described in the 1934 article. It consists of a cylindrical glass envelope with a plain circular cathode at the left and an anode enclosed in a pencil-shaped shell, called "target," at the right. The end face of the tube consists of plane glass of optical quality, and through this end plate an optical image of the object to be televised is formed on the face of the cathode. Since the surface of the cathode is photosensitive, electrons will leave each point of this surface in an amount corresponding to the illumination in the image at that point. These photoelectrons are pulled toward the anode by means of a high potential applied between the anode and the cathode. If no other arrangements were made, the electrons leaving any one point in the cathode would not all travel toward the anode in an axial direction, but would fan out in a narrow cone. However, by enclosing the entire tube in a solenoid and passing a direct current of the proper amplitude through this solenoid, it is possible to pull this cone of electrons together again in such a fashion that all electrons leaving any one point on the cathode will again come together in one point of a plane parallel to the cathode and located in the plane of the target. This focusing action is indicated by the curved electron patterns shown in Fig. 17. In other words, it is thus possible to insure that a complete electron image of the scene is reproduced in the plane of the target. The target has a small aperture facing the cathode and, by sweeping the entire electron image back and forth and up and down past this aperture, the electrons of each element of the image are made to pass successively through this aperture and reach the anode inside. That is, by the scanning of the electron image past the aperture, the image is "dissected" into its elemental areas, and a signal is produced which at each instant is proportional to the number of electrons entering the aperture at that instant, and therefore again proportional to the light falling on the corresponding point of the cathode at that same instant. The tube therefore is instantaneous in nature and no storage is involved. The sweeping of the electron image is effected by means of two sets of sweep coils placed at right angles around the cylindrical sides of the tube and energized by saw-tooth currents of the proper frequencies.

The earliest forms of dissectors built by Farnsworth were quite insensitive as compared with modern type tubes. In order to obtain television signals with any reasonable signal-to-noise ratio, it was necessary that the illumination in the optical images formed on the cathode be extremely high. This, in turn, meant that live pickup from studio scenes was out of the question since the required image illumination could be obtained only from lantern slides with high-intensity light sources. In order to remedy this situation, Farnsworth therefore replaced the original photocell with an electron multiplier capable of multiplying the original photocurrent by many orders of magnitude. The development of electron multipliers for this and other purposes will be discussed later.

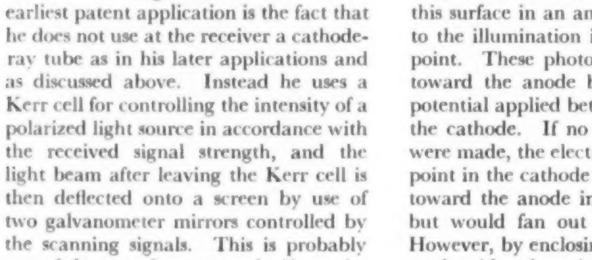


Fig. 16. Early German proposal for live pickup using cathode-ray tube spot scanner (von Ardenne, 1930).

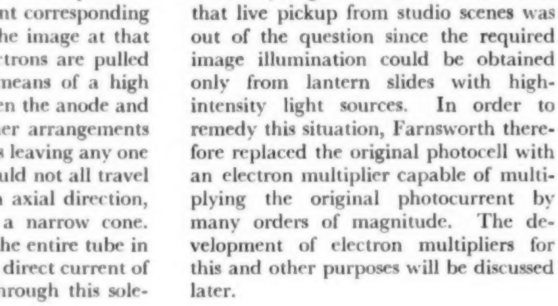


Fig. 17. Diagrammatic view of Farnsworth's dissector camera tube (1934).

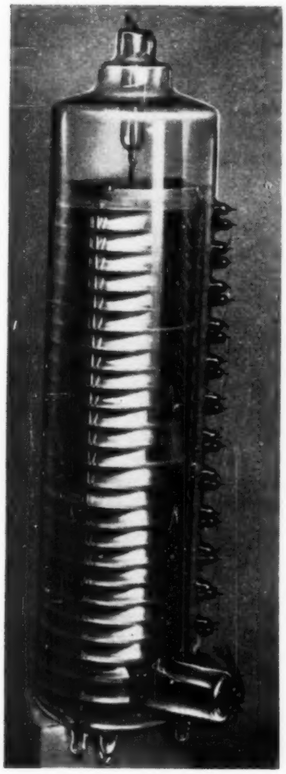
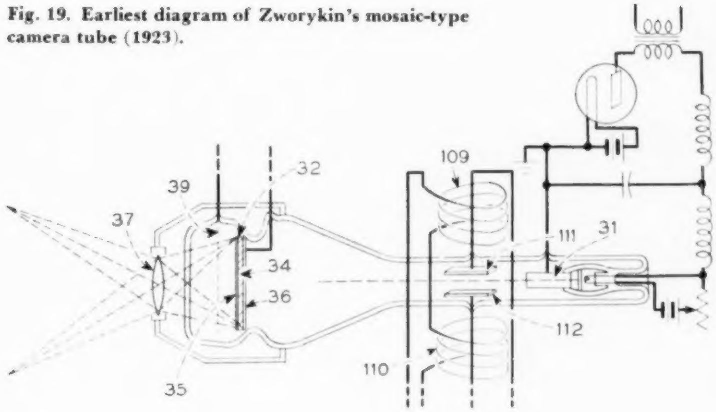


Fig. 18. Special Farnsworth dissector camera tube (Bell Telephone Laboratories, 1945).

Fig. 19. Earliest diagram of Zworykin's mosaic-type camera tube (1923).



In the late 1930's dissector tubes with electron multipliers were used in television cameras for live pickup and demonstrated by Farnsworth, but even these later type tubes required studio lighting which was uncomfortably intense and the tubes were never used in any commercial television cameras. The tube, however, has been used very successfully in many types of motion-picture film scanners, although present types of commercial film scanners all use storage-type tubes. It also has been used and still is being used for several applications of industrial television, such as the reading of instruments in inaccessible or dangerous locations. It should be mentioned that the great advantage of the dissector tube over storage-type tubes is that it is completely linear in operation so that the output signal is strictly proportional to the light falling on the cathode. This is of particular advantage when scanning motion-picture film and was the principal reason for the use of the dissector tube for this purpose until the advent of the short-decay, cathode-ray tube flying-spot scanner.

Figure 18 shows a photograph of a special type of dissector tube designed for use in an experimental motion-picture scanner which was used in the Bell Telephone Laboratories until quite recently.[21]

B. The Iconoscope

The storage-type camera tube was invented by Zworykin and was first described in a patent application dated December 29, 1923.[11] Figure 19 shows a cross-sectional view of the tube as taken from this application. The right end of the tube shows the cathode and a cylindrical anode (31), and through this a beam of electrons is directed toward the target (32). This target has the characteristic mosaic structure consisting of a wire mesh screen (36) facing the cathode, a thin insulating layer (34) behind the wire screen, and a layer of insulated globules of photoelectric material (35) deposited on the insulating layer. This photoelectric mosaic thus faces the camera lens (37). By means of this lens the scene to be televised is imaged on the mosaic. It will be noticed that both electrostatic and electromagnetic deflection are used in this type. The tube was argon-filled and used gas focusing of the beam and, according to the description in the patent, this gas also played a part in the collection of signal current from the mosaic onto the signal grid (39). However, the exact nature of this collection is not very clear. Tubes of this sort were constructed by Zworykin in 1924, and Fig. 20 is a photograph of one of these early tubes. It was mentioned earlier that Zworykin demonstrated the use of such a camera tube in an all-electronic system using a cathode-ray tube at the receiver sometime during 1924, but that the pictures were scarcely more than shadow pictures with rather poor definition.

After spending the next few years in improving the cathode-ray tube at the receiver, Zworykin again took up the construction of camera tubes when he joined RCA around 1930. A description of an early form of iconoscope is given in an article by Zworykin in the *Proceedings of the I.R.E.* in 1934,[22] and Fig. 21 shows a cross-section of a tube used in these experiments. By this time it had been realized that proper focusing of the electron beam could be obtained only in a high-vacuum tube with proper design of focusing electrodes, as described earlier in the section on Cathode-Ray Tube Receivers. The tube has a signal plate consisting of a thin metal plate on which is deposited a thin layer of insulating material (in modern iconoscopes this insulating layer consists of a thin sheet of mica), and on top of the insulating sheet is deposited a mosaic consisting of a large number of minute globules of photosensitive material. The globules are insulated from each other and are small enough so that the cross-section of the beam covers a large number of globules at any one time.

The method of operation of the iconoscope may be described in a somewhat simplified form as follows. An object is imaged on the mosaic by means of a camera lens and, as the globules are illuminated by this image, they give off photoelectrons which leave the mosaic and are collected by a collector electrode marked "Pa" in the figure. As the photoelectrons leave the mosaic, the globules are thus charged positive with respect to the signal plate, and the greater the illumination the more the globules are charged and, therefore, the higher the potential between the globules and the signal plate. This goes on as

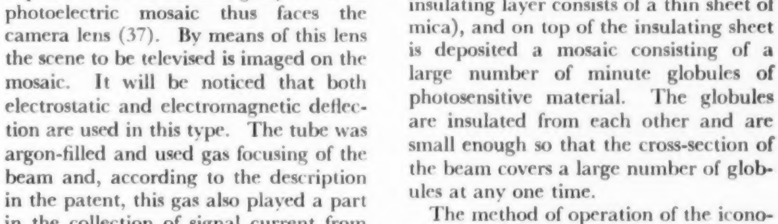


Fig. 20. Earliest experimental model of Zworykin camera tube (1923).

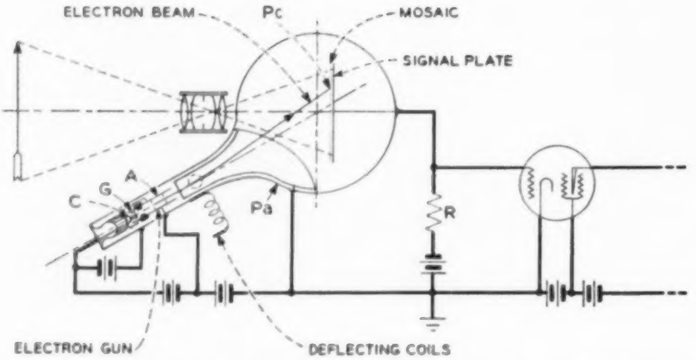


Fig. 21. Diagram of earlier model of Zworykin's iconoscope camera tube (1934).

long as the target is illuminated and the action, therefore, is cumulative. An electron beam from the cathode of the tube is made to scan over the mosaic in the usual manner by means of two sets of magnetic coils placed around the neck of the tube. As the scanning beam strikes the globules on any one point of the mosaic, these globules are thereby discharged and the discharge causes a corresponding pulse of current to flow from the signal plate to ground through the resistance, R. The varying potential across this resistance therefore constitutes the television signal. As soon as the beam has left a particular spot on the mosaic, this spot will again start to charge up in accordance with the light falling on it and will continue to do so until the beam strikes it again during the succeeding scan. In other words, energy is stored up in the mosaic by the action of light on the photoelectric globules, and this storage continues during the entire period between scans. This storage principle makes the iconoscope much more sensitive than the dissector tube, which depended for its action on the photoelectric emission from the cathode at any one instant.

The actual mode of operation of the iconoscope is somewhat more complicated than described above, due to the fact that secondary emission takes place as the beam scans over the mosaic. The potential between the cathode and the anode is quite high, of the order of a thousand volts or so, and therefore results in a high velocity electron beam. As this beam strikes the mosaic it releases secondary electrons from the mosaic, and these secondary electrons are partly collected by the collector electrode but also partly pulled back onto the mosaic in a more or less random manner. Even if the mosaic were not illuminated by any image, such secondary emission would still take place and some of these secondary electrons would be pulled back to the mosaic and redistributed over the surface, thus giving rise to a false signal current. These spurious signals are called "shading" signals and are common to all iconoscope and other high velocity beam tubes. Since the secondary electrons are redistributed over the mosaic in a rather broad fashion, the resulting shading signals are low-frequency signals of rather simple waveforms, and they may therefore be compensated for by introducing a corresponding correcting signal from special shading signal generators incorporated as part of the camera equipment. A photograph of an early iconoscope of the type described above is shown in Fig. 22.

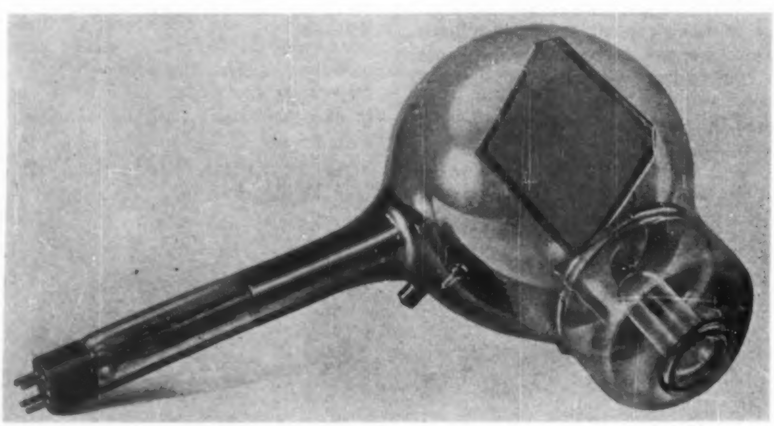


Fig. 22. Early iconoscope camera tube.

Due to the storage action of the iconoscope, this tube theoretically should be some 50 to 100 times more sensitive than an instantaneous-type tube like the dissector (assuming that the dissector does not incorporate the use of an electron multiplier). Actually, the iconoscope is only some 5 to 10% efficient due to the secondary emission. In the first place, the secondary electrons released from the mosaic reduce the electric field in front of the mosaic and therefore make the photoemission of the globules less efficient; also, the fact that the secondary electrons are only partly collected by the collector electrode results in lower charging potentials of the globules and, therefore, in lower signal current. Even so, the inconoscope proved to be a much more sensitive tube than any tube hitherto produced and made it possible for the first time to build live pickup cameras for studio use with studio illuminations that were not too uncomfortable for the actors.

The number of secondary electrons emitted from any part of the mosaic depends on the potential of the mosaic at the time the electron beam strikes it, and this again depends on the amount of light falling on the mosaic at that point. The result is that the overall action of the iconoscope is not linear, that is, the output current is not proportional to the amount of light falling on the mosaic. The relation between illumination on the mosaic and signal output current is more nearly a square root relation for small values of illumination, and for large values it soon reaches a saturation point, so that increased illumination results in only very little increase in corresponding signal output.

For studio use the iconoscope has long since been superseded by more modern forms of camera tubes, but it is still extensively used in motion-picture film scanners. The tube shown to the right in Fig. 27 is a photograph of a modern-type iconoscope for this use.

C. *Image Iconoscope*

The first step towards further improving the iconoscope was the so-called image iconoscope, which was first described in an article by Iams, Morton and Zworykin in the *Proceedings of the I.R.E.* in 1939.[23] Figure 23 shows a cross-sectional diagram of such a tube, as

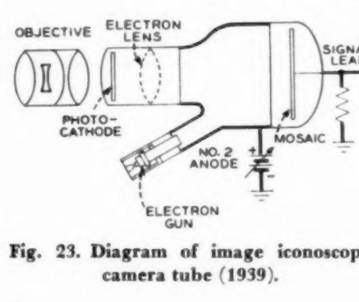


Fig. 23. Diagram of image iconoscope camera tube (1939).

taken from that article. The tube has a semitransparent photocathode on which an optical image is formed of the scene to be televised. As light falls on the photocathode, photoelectrons are emitted from this cathode and are pulled towards the mosaic at the right by means of a high electric potential. Close to the photocathode there is, in other words, an electron image corresponding to the optical image falling on the cathode, and by means of an electron lens system this electron image is focused in the mosaic in the same manner as described earlier for the dissector tube. The electron lens system may be either magnetic and consist of a coil, as in the case of the dissector, or it may be electrostatic and consist of a series of metal rings of proper potential.

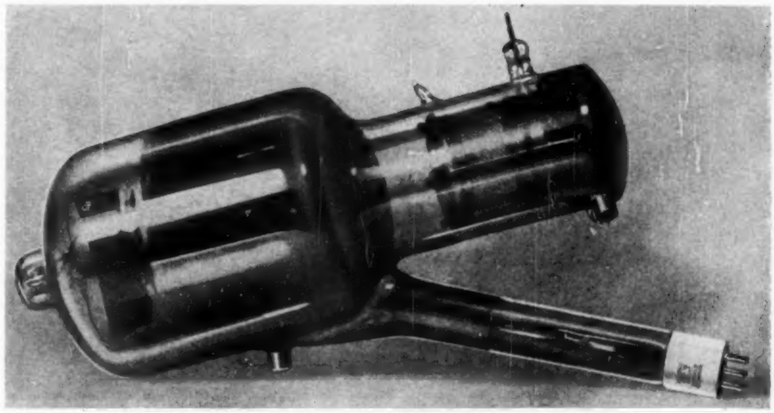


Fig. 24. Image-iconoscope camera tube (1939).

Since the potential between the photocathode and the mosaic is high, the photoelectrons reach the mosaic and therefore give rise to the emission of secondary electrons from the mosaic. Since each incoming electron releases on the order of 4 or 5 secondary electrons, this in effect results in a charge image on the mosaic which is 4 or 5 times higher than if no secondary emission took place. On top of that, the high field between the photocathode and the mosaic results in a more efficient collection of current from the photocathode than in the case of the iconoscope, where the field near the photosensitive mosaic was reduced due to secondary emission. All in all, this arrangement results in a tube which is about ten times more sensitive than the ordinary iconoscope. Figure 24 shows a photograph of an image iconoscope for use in a studio camera. Tubes of this type were used here in the United States during the 1940's but were later replaced by the image orthicon. However, in England tubes of this type are used extensively for studio cameras. The English name for this type of camera tube is Super Emitron.

D. *The Orthicon*

It was mentioned above that the iconoscope was only 5 to 10% efficient. Due to secondary emission, only a small part of the photoelectrons emitted by the mosaic are drawn away and only a small part of the stored charge is effective in producing a signal. The image iconoscope is one attempt to improve this efficiency, but another and rather different approach consists in using a low-velocity electron beam for scanning. In this case it is possible to provide at the mosaic a field strong enough to draw away all the photoelectrons and, furthermore, no secondary electrons are emitted when the beam reaches the mosaic.

A tube of this type, called the orthicon, was developed at the RCA Laboratories, and is described by Rose and Iams in an article in *RCA Review* in 1939.[24] Figure 25 shows a cross-sectional diagram of this tube. The tube has a storage-type mosaic plate similar to that used in an iconoscope, and when light falls on this plate all the photoelectrons are drawn to the collector by means of a sufficiently high potential between the collector and the mosaic plate. In this case, however, the mosaic plate is kept at a potential equal to that of the cathode, and when the electron beam reaches the signal plate it therefore has zero velocity and does not release any secondary electrons. If the mosaic has been charged up due to light falling on it, the electron beam just resupplies the electrons that have left the mosaic due to photoemission and thus brings that part of the mosaic back to cathode potential. The remaining electrons in the beam thereafter return to the collector. The signal thus consists of the current pulses flowing in the output lead as each successive point of the mosaic is being discharged.

Since the electron beam in this tube has very low velocity, it would not stay sharply focused as it traverses the tube unless special precautions were taken. These consist in focusing coils arranged around the tube in such a manner as to produce a strong longitudinal magnetic field. This field has the effect of keeping the beam concentrated as it traverses the tube so that the cross-section of the beam at the mosaic is about the same as that leaving the gun. In order to avoid blurring near the edges of the mosaic it is further necessary to introduce correcting fields which insure that the beam is perpendicular to the mosaic over the entire surface. One of the great advantages of this type of tube is that no secondary emission takes place. For this reason the tube is nearly linear in operation and, furthermore, this also results in a complete absence of spurious shading signals. Tubes of this sort were built and used experimentally in pickup cameras. However, the tube was soon to be superseded by a still more efficient and sensitive tube and therefore never came into wide use.

E. *Image Orthicon*

In the description of the orthicon it was mentioned that the electron beam supplies to each part of the mosaic the electrons that have been lost by the electron image, and the remaining part of the electrons then return to the collector. This return beam, therefore, is in effect modulated by the signal current and,

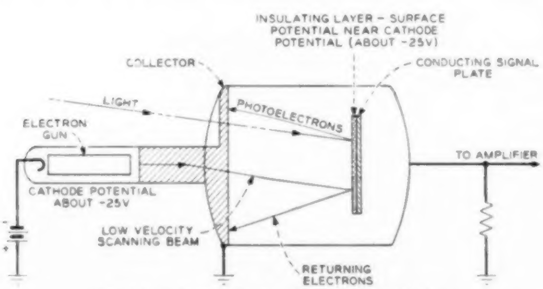


Fig. 25. Diagram of orthicon tube (1939).

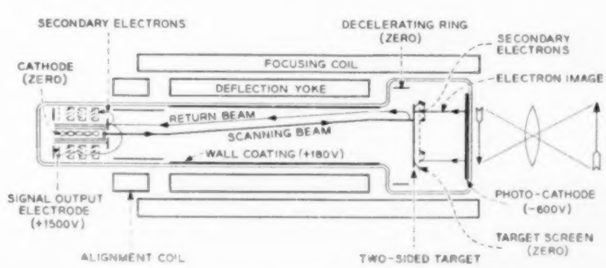


Fig. 26. Diagram of image-orthicon tube (1946).

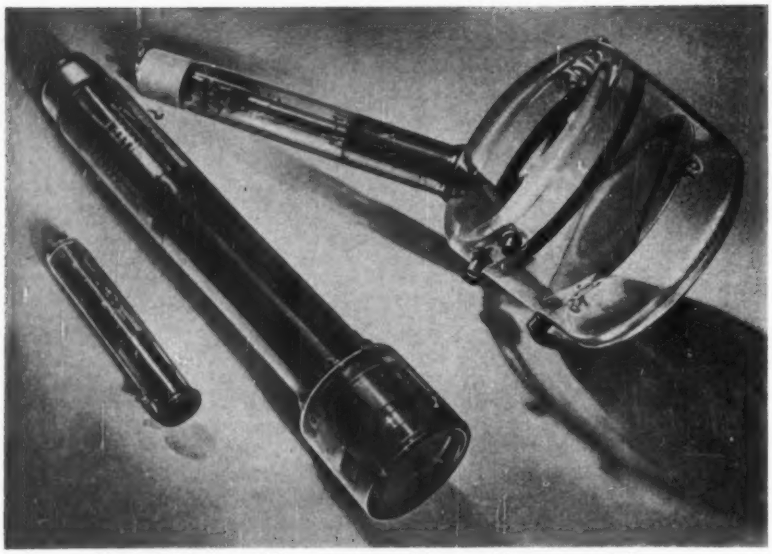


Fig. 27. Modern vidicon, image-orthicon and iconoscope tube.

if properly collected, could indeed be used as the signal. This is one of the principles employed in the image-orthicon tube which was developed by RCA and first described in an article by Rose, Weimer and Law in the *Proceedings of the I.R.E.* in 1946.[25] Figure 26 shows a cross-sectional diagram of this tube which makes use of electron image amplification, as in the image iconoscope, of the efficient low-velocity beam, as in the orthicon, and of an electron multiplier, as in the later types of dissectors. The optical image is formed on a transparent photocathode placed on the inside of the end glass wall of the tube. The electron image emitted from this cathode is focused as a second electron image in the plane of a thin two-sided insulating target. Since a high electric field exists between the photocathode and the target, the photoelectrons strike the target with high velocity and give rise to the emission of secondary electrons, with the result that the charge image on the target is some 4 or 5 times stronger than the electron image leaving the photocathode. The other side of the target is scanned by a low velocity electron beam which discharges points of the target as it scans across it, thus resulting in a return beam which is modulated with this discharge current. As in the orthicon, the electron beam is kept focused during its traverse from electron gun to target, and the same focusing field will therefore keep the return beam focused along the same path so that the return beam strikes the plate surrounding the gun aperture very close to this aperture. It strikes these plates with a velocity high enough to release secondary electrons and, by proper electrostatic focusing, these secondary electrons are in turn guided to the first dynode of a multistage electron multiplier located behind the gun. By thus making use of all the known methods of electron magnification it has been possible to construct a camera tube which is of the order of 100 times more sensitive than any previous type of camera tube. With tubes of this sort, it is possible to make television pictures at very low light levels and, in fact, when using television cameras with this type of tube it has been possible to televise outdoor scenes at light levels so low that no satisfactory motion picture could be obtained. When used in the studio this tube produces excellent television pictures at medium light levels and is now the tube most commonly used for all studio cameras in the United States. A photograph of a modern image orthicon is shown as the center tube in Fig. 27.

F. The Vidicon

One of the earliest discoveries in the field of photoelectricity was that of the photoconductive properties of selenium. Selenium was discovered in the early part of the 19th century and was found to have a very high electrical resistance. In 1873 Willoughby Smith in England was making experiments with submarine cables and, in connection with those tests, he had use for some very high resistances.[6] He therefore had made up some long wires of selenium enclosed in glass tubes, with the idea of using these as resistance elements. He found, however, that he could not obtain constant results in his measurements. The results varied from day to day for no apparent reason and, in an attempt to discover the cause of the discrepancies, Smith accidentally covered one of the selenium wires, excluding the light falling on the wire, and he found that it suddenly changed its resistance materially. Smith published his discovery, which caused great excitement and gave rise to many of the early proposals for "seeing by electricity." When Swinton tried to build a mosaic for his camera tube, it was selenium he thought about as a photoelectric material, and most of the other early experimenters thought in terms of selenium when translating light energy to electrical energy. It is interesting to note that, in spite of this early discovery of the photoconductive property of selenium, it was not until 1950 that a satisfactory photoconductive camera tube was built, a tube capable of producing the high-definition television signal required for modern television. It took the technique over half a century to catch up with the ideas and visions of the early inventors.

During the late 1940's the engineers at RCA experimented with an RCA photoconductive pickup tube, and in 1950 such a tube was described in an article by Weimer, Forgue and Goodrich appearing in *Electronics*.[26] They called the tube the vidicon, and Fig. 28 shows a cross-sectional diagram of such a tube

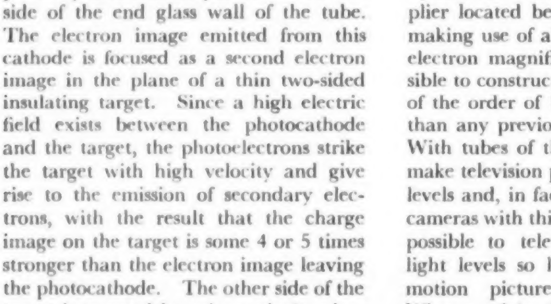


Fig. 28. Diagram of vidicon camera tube (1950).

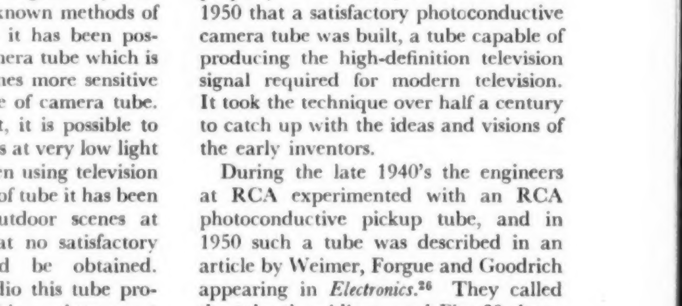


Fig. 29. Diagram of early electron multiplier amplifier tube (1926.)

as taken from the article mentioned. The tube uses a low-velocity scanning beam similar to that used in the orthicon, but instead of the photoemissive surface in the orthicon the vidicon uses a photoconductive target deposited on a transparent conductive signal plate. An optical image of the scene to be transmitted is focused onto the photoconductive surface through the transparent signal plate. This signal plate is kept at a potential of about 20 v positive with respect to the cathode, and when no light falls on the photoconductive surface this surface is kept at cathode potential by means of the scanning beam. When light falls on the photoconductive surface it increases the conductivity, and a charge current flows from the signal plate to the individual elements of the photoconductive surface, the charging current being proportional to the amount of light falling on the surface. When the scanning beam strikes the charged surface it deposits sufficient electrons to neutralize this charge and thereby generates the video signal in the signal plate lead. In other words, the operation is very similar to that of the orthicon except that the positive charging effect is achieved by photoconduction through the target itself rather than by photoemission from the scanned surface.

The advantage of using a photoconducting tube rather than a photoemissive tube is that the sensitivity of photoconductive materials is such that currents of several thousand microamperes per lumen may be obtained as compared to 30 to 50 μa/lm for the most efficient photoemissive materials. Thus a highly sensitive camera tube may be built without the additional complication of an electron image amplifier and an electron multiplier as incorporated in the image orthicon. This results in a simpler tube which is cheaper to build and can be made much smaller and more compact than any other camera tube. The photograph to the left in Fig. 27 is of a vidicon tube capable of producing satisfactory television pictures of more than 600 lines. It is about 6 in. long and 1 in. in diameter, and with tubes of this sort it has been possible to build portable field cameras that are not much bigger than an ordinary 16mm motion-picture camera.

Multiplier Phototubes

A multiplier phototube or photomultiplier is a photocell in which the photoelectrons emitted by the photosensitive surface are amplified inside the tube by making use of the phenomenon of secondary emission. The photoelectric effect itself was first discovered by Hertz in 1887, and photoelectric cells of the type we now know were first experimented with around 1900. The use of secondary emission as a means of amplification was first made use of by A. W. Hull in a patent application dated 1915.[27] This application deals with the use of a dynatron as a device having negative electrical resistance characteristics. A second patent application by Hull, dated December 28, 1921,[28] deals with a vacuum tube amplifier which makes use of secondary emission to obtain increased amplification. Another electron multiplier amplifier is described in a patent application by Jarvis and Blair dated September 15, 1926.[29] Figure 29 shows a cross-sectional diagram of the amplifier taken from this application. In this amplifier tube, electrons from the cathode (1) are controlled by the grid (2) in the usual manner, and from there they flow to the first anode (16) which corresponds to the plate in an ordinary vacuum tube. If this anode is of the proper potential, the electrons striking it will have sufficiently high velocity so that each electron releases several secondary electrons. By means of electrostatic shields (5) of proper potential, these secondary electrons are guided to the next anode (17) which they strike, and release still more secondary electrons, and so on, through the entire tube until finally the multiplied electrons reach the collector plate at the end of the tube. With the proper potential gradient from anode to anode, and with the anodes made of the proper material, it is possible to insure that each primary electron striking an anode will release as many as 4 or 5 secondary electrons, and with enough stages of multiplication it is thus possible to obtain an electron multiplication of many thousand times.

If, in the tube shown in Fig. 29, the cathode and the grid are replaced by a photosensitive surface on which light can be projected, we have, in effect, a photomultiplier very similar to the type used nowadays. During the early development of photomultipliers some of the forms utilized external magnetic focusing or guiding of the electrons through the tube, but all of the photomultipliers used today employ electrostatic focusing similar to that described above. It is multipliers of this type that were used by Farnsworth in his later developments of the dissector tube, and it is also this type of multiplier which is employed in the image orthicon.

Motion-Picture Film Scanners

During the late 1930's it was established that future commercial television in the United States would use 30 frames/sec, that is, 60 fields interlaced. With regard to the scanning of motion-picture film, this created a problem, due to the fact that motion pictures are presented at 24 frames/sec, and some form of translation from 24 to 30 frames/sec was therefore necessary.

The problem was solved by using a storage type of camera tube as a pickup device in the scanner. The motion-picture film was run in the usual intermittent fashion at 24 frames/sec, and the mosaic of the camera tube was illuminated by the image using very short flashes of intense light at the rate of 60/sec. These flashes were made to occur during the field blanking intervals of the television signal, and the mosaic was then scanned in the usual manner while the film was being pulled down to the next frame. Thus every other picture frame is scanned twice and the intervening frames three times in order to produce the 60/sec field scan.

The tube most commonly used for film scanners was the iconoscope and, in fact, many film scanners using the iconoscope are still in use in the broadcasting studios. As mentioned above, under the Iconoscope Section, this tube produces a spurious shading signal, the nature of which depends to some extent on the distribution of light in the image. This therefore creates an additional problem since sudden changes of scene in the film give rise to sudden changes in the shading signal. Satisfactory operation of such a film scanner calls for highly skilled personnel and, in general, requires rehearsals in order to insure prompt and accurate modifications of compensating signals when the scene changes. On top of this, the iconoscope is not capable of producing a range of tone gradations that is anywhere near that obtainable in high-grade motion-picture film.

For these reasons, television pictures from motion pictures have generally been quite inferior to those obtained with live pickup, and many attempts have been made to design a motion-picture film scanner capable of using a cathode-ray tube spot scanner as the light source, since this would result in a much better tone gradation and the absence of shading signals.

In order to accomplish this it is necessary to use a continuous or nonintermittent film drive and to incorporate in the machine a system of rotating mirrors or prisms so arranged that the scanning raster imaged onto the film via these mirrors is made to follow the motion of the film, and thus is capable of scanning the film as if the frames were stationary.

Continuous projectors with this type of optical arrangement have been known for a long time, and in one particular form were used quite extensively for commercial film projection in Germany in the 1930's. This projector was designed by Mechau, and a detailed description of its design and operation was given in 1928.[30] The optical arrangement of the projector is such that, as the film is pulled through the gate in a continuous motion, the light projected through the film passes via a series of mirrors moving in such a fashion as to keep the image of the film frame stationary on the screen. As one

film frame leaves the gate, the image of this frame fades out and the image of the succeeding frame fades in. In other words, the picture on the screen consists of a continual lap-dissolve from one frame into the next.

If a machine of this sort is used backwards, that is, with a cathode-ray tube scanning raster in place of the screen and with a photomultiplier in place of the light source, then it fills all the requirements for a continuous motion-picture television scanner. In fact, quite a number of these Mechau machines were brought to England before and after the last war and are still being used by the British Broadcasting Corp. for film scanning and kinerecording.

In the United States a continuous film scanner made on a principle somewhat similar to Mechau's was designed and constructed in the Bell Telephone Laboratories around 1948.[31] It uses a system of moving mirrors like the Mechau, but the mechanical arrangement for controlling these mirrors is greatly simplified over that used in the Mechau machine. This machine is still used as a main source of television signals in the Laboratories and is capable of producing pictures with a detail corresponding to some 7 or 8 mc and with contrast ranges corresponding to theater release prints.

Lately several firms have brought on the market commercial film scanners using continuous film motion and a rotating prism as the moving optical element. Film scanners of this type are particularly significant since they greatly simplify the problem of scanning motion-picture film in color.[32]

It should be mentioned that in the last few years the advent of the image orthicon and the vidicon has made it possible to build intermittent-type film scanners with performance capabilities much higher than those of the original iconoscope film scanner, and such scanners are now being used to an increasing extent in the broadcating studios.

In England television pictures are scanned at the rate of 25 frames/sec or 50 fields interlaced. By simply running the motion-picture film continuously at the rate of 25/sec instead of 24/sec, it has therefore been possible for the British to construct and use very high-grade cathode-ray tube spot scanning machines with very much simpler optical arrangements than are required here in the United States. A description of two different types of such film scanners was given at the Television Convention in London in 1951.[33]

Development of Television Standards in the United States

It was long ago realized that in order to insure adequate synchronization between television transmitters and television receivers it is essential to establish a "lock-and-key" relationship between the two. It was therefore also realized that a widespread commercial television service would require a set of nationally adopted systems standards insuring such a lock-and-key relationship.

As early as 1929 the Radio Manufacturers Association set up a committee on television for the purpose of coordinating and guiding the experimental television work going on at that time. By 1935 this committee was requested to investigate the possibility of setting up a set of television standards for nationwide use, and by 1936 such a set of standards had been proposed and a report submitted to the Federal Communications Commission.

In this report it was recommended that seven television channels be allocated in the region from 42 to 90 mc and that each channel should be 6 mc wide. It was proposed that the system should consist of a 441-line picture and the transmission recommended was a double sideband AM transmission of the picture signal with 3.25-mc separation between the sound and the picture carriers. By August 1936 the Federal Communications Commission permitted experimental transmission of such signals in part of the frequency band proposed but took no further action on the standards since the transmissions were still experimental only.

During the next couple of years further developments resulted in a modified set of standards which was submitted by the Radio Manufacturers Association to the Federal Communications Commission in 1938 with the proposal that they be adopted as national standards. Furthermore, the National Broadcasting Company announced that, coinciding with the opening of the New York World's Fair in 1939, they would start a limited series of programs in accordance with these standards. By this time the standards recommended made use of vestigial sideband transmission, which enabled the frequency range occupied by the picture signal to be increased from about $2\frac{1}{2}$ mc to 4 mc.

NBC maintained such a program all through 1939 without any formal approval of the standards by the FCC, but in the latter part of 1939 the FCC issued a ruling which permitted limited commercial sponsorship of such transmission and announced their intention of holding a hearing in January 1940 for the purpose of arriving at a set of standards having general industry support.

During the hearing it developed that serious objections to the RMA proposed standards were raised by several sectors of the industry, and in the report of the hearing the FCC stated that commercialization would not be permitted until the industry agreed on one common system of broadcasting.

In order to establish such a system, the National Television System Committee was set up under the sponsorship of RMA. This Committee consisted of a group of technical experts from all interested parts of industry, and during the next year and a half this Committee concentrated on the formulation of a complete set of television standards supported by the industry as a whole. The final report of the Committee was delivered to the Commission in March 1940, and in May of that year the FCC announced that the NTSC standards had been adopted officially and that commercial television broadcasting based on these standards would be permitted as of July 1941.

By this time the standards called for a picture having 525 lines and, except for minor modifications, the standards were identical to those now in force. During the war years commercial television was temporarily discontinued except for a few special transmissions, and in 1945 the prewar standards were reaffirmed by the Commission with a few minor modifications. These reaffirmed standards are the present commercial standards for black-and-white television transmission in the United States.

A very complete report on this standardization work inside RMA and NTSC was assembled by D. G. Fink and published by McGraw-Hill in book form in 1943.[34]

The Development of Television Network Facilities

The first transmission of television signals over Bell System wire facilities took place in April 1927 when signals produced by Dr. H. E. Ives' mechanical-scanning arrangements were transmitted from Washington to New York.[35] At the same time, signals were also transmitted by radio from Whippany, N.J., to New York.[36] These signals were of the low-definition type produced at that time and required a band-width of only about 20,000 cycles.

Television signals approaching the present-day wide-band variety were first transmitted over the coaxial cable from New York to Philadelphia in 1937.[2] The pictures were produced from motion-picture films by means of a 6-ft scanning disc. Two hundred and forty lines per frame were used and the band-width required to transmit the signals was 800,000 cycles. In 1940 television signals were transmitted over the coaxial cable from New York to Philadelphia and return, but now the signals corresponded to 441-line television pictures and required a frequency band of about 2.7mc.[37] Later that year scenes from the Republican National Convention in Philadelphia were transmitted over the coaxial cable to the National Broadcasting Co. studio in New York for television broadcasts. During 1941 similar

television signals were transmitted over coaxial cables for a total distance of 800 mi. by looping the coaxial units in the cable between Stevens Point, Wis., and Minneapolis.

During the war years very little television transmission took place, but after the war, in 1945, television service was furnished to the broadcasters on an experimental basis between New York and Philadelphia and New York and Washington, with dropping points at Baltimore. These signals were of the 525-line variety now used for commercial broadcasting.

In 1947 the first microwave relay system was inaugurated between New York and Boston, and a round-trip television signal from New York was sent to Boston and back again and was received both in New York and, in addition, in Washington over the coaxial cable from New York.[38]

In 1948 commercial service over Bell System networks was started and since that time the number of channel miles available for transmission has grown steadily, both over the coaxial system and over the microwave relay system. The Chicago-New York radio relay link was started in 1950, and the first commercial program transmission from coast to coast over the radio relay took place in September 1951 when President Truman spoke in San Francisco, and signals were broadcast from stations in New York City.[39]

At the end of February 1954, the total number of channel miles available for television transmission in the United States was about 52,000, of which 17,000 were coaxial and the remaining 35,000 microwave relays.

The establishment of satisfactory long-distance television transmission facilities has imposed some extremely severe requirements on the reliability and stability of the individual components of such systems. The reception of a satisfactory broadcast television picture, especially for color television, requires that the studio equipment, the transmitting equipment and the receiving equipment together provide a channel which has a gain characteristic flat within a fraction of a decibel over the entire band and for which the departure from phase linearity over the band is only a few degrees. When such a television signal is transmitted over a coaxial cable from New York to Chicago, it passes through over a hundred repeaters, each with a gain of about 40 db, or a total gain of over 4000 db. In order to insure that the television signal still meets the above-mentioned requirement after transmission over such a system, it will be realized that the design of the individual components requires extreme accuracy and care in order to insure the necessary precision and stability of both the repeaters themselves and their associated passive equipment, such as amplitude and phase equalizers. Similar stringent requirements exist for the components in microwave relay systems since the signal transmitted over such a system from New York to Los Angeles again has to pass through over a hundred repeaters on the way.

Conclusion

The purpose of this paper has been to sketch the development of modern television from the early days of mechanical scanning through the transition period of partly mechanical and partly electronic scanning up to the present-day all-electronic systems of high-definition television. This paper deals only with black-and-white television; the development of color television has not been included, partly because color television has only just been made commercial and a historical paper on this subject may therefore be somewhat premature, but partly also because this entire subject by itself has a long and interesting history and therefore merits a separate paper of its own.

Apart from some of the early historical developments, the author has limited himself largely to the development here in the United States, but for those readers interested in the development of television in England and in Germany, the author would refer them to two very excellent papers published during the last couple of years, one in the *Proceedings of the Institution of Electrical Engineers* in 1952[40] and the other in a German magazine article mentioned previously.[4] Both these papers are very extensive and both have excellent bibliographies, which will prove valuable and time-saving to any reader interested in source material.

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Factors Affecting Application of Soundtrack Developers to Color Films

By ROBERT C. LOVICK and RICHARD L. WHITE

Silver deposits provide the simplest means of obtaining satisfactory sound reproduction from color films when the phototube has the standard S-1 response. Some factors are discussed affecting the dimensional characteristics of redevelopers applied by roller or extrusion methods. The formula of a new soundtrack developer for the Eastman Color Print Films is given. The method of selecting coating aids may be useful for determining satisfactory materials for other processes requiring dimensional stability of applied solutions.

Dimensional Requirements

Thirty years ago the few sound records that accompanied motion pictures were not a part of the photographic record. The introduction of photographic sound resulted in the standardization of soundtrack position in proximity with the pictures. Dimensional tolerances were established[1,2] with consideration of mechanical and optical factors only, since picture and sound prints were processed simultaneously.

The introduction of color required conformance to the established tolerances although for practical processing reasons the tolerances are more difficult to meet. Color films can be exposed or printed in the same equipment as black-and-white films and with the same accuracy. Difficulty arises because the sensitometric requirements of the pictures and the soundtracks on color films necessitate different development processes for each when the sound is reproduced with a phototube having an infrared sensitivity. The limiting factor for the dimensional characteristics now is the soundtrack development.

Sensitometric Requirements

The present sensitometric relationship between sound negatives and prints was evolved from the requirements of early black-and-white pictures. Negative and print gammas were well established before photographic sound became practical. Sound-recording materials were formulated and manufactured to provide optimum quality with release-print materials. It has been found economically desirable for color-print materials to have characteristics which permit the use of negatives suitable for printing on black-and-white film as well as color.

A most important requirement is that the sensitometric characteristic of the soundtrack deposit be compatible with the sound negative for low distortion. Theoretically, the choice of material forming the track deposit is unimportant, but it assumes importance because of the virtual standardization of a particular receptor response.

The deposit formed in the first soundtracks consisted of silver only. The density versus wavelength curve of a photographic silver deposit on a typical release positive is shown in Fig. 1. Density is fairly constant over most of the visual and near-infrared spectrum. Therefore, phototube receptors used in reproducers might have a peak sensitivity anywhere in this region and be acceptable. However, at the time photographic soundtracks were intro-

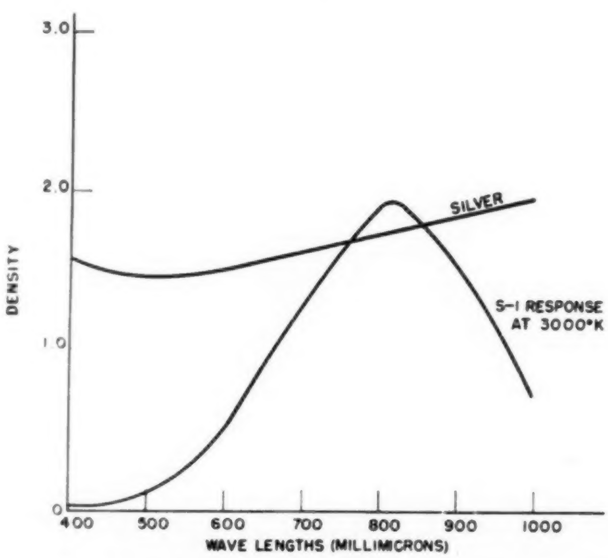

Fig. 1. Spectral density of silver deposit on positive-type film and response of standard S-1 photosensitive receptor.

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duced, the design of amplifiers and phototubes was such that gas-filled phototubes with peak sensitivities in the near-infrared had to be used in a practical system. A typical receptor response is that of an S-1 surface, also shown in Fig. 1.

Since reproducers were designed to operate with the infrared-sensitive phototube, soundtracks on color films had to have useful absorption at these wavelengths. Figure 2 shows the spectral density characteristics of the dyes in a particular color film. Dyes alone in color films at any practical concentration will not produce sufficient density in the infrared region. Receptors with maximum response in the visual instead of the infrared region have been avoided because of the concern that the use of dye sound records associated with a particular response in the visual region might limit future developments of photographic color reproduction. Furthermore, only recently have gas-filled phototubes become available with a high sensitivity in the visual region (S-4 response) capable of giving output comparable with the S-1 gas-filled phototubes.

The sound-reproduction capabilities of a dye deposit can be made nearly equal to that of a silver deposit. However, the dyes produced in color films are selective absorbers. Selective absorbers will introduce variations in sound reproduction because of differences in the wavelength of maximum response of phototubes. Minimization of the distortion which would result from a change of spectral response of the receptor requires the use of at least two dyes. Frequency response is affected by the position of the track-deposit layer in the emulsion. The use of two dye layers would result in different frequency responses from phototubes having different spectral responses. The less selective an absorber, the less variation expected of all sound-reproduction characteristics. Silver deposits are relatively nonselective absorbers. In addition, since the silver of any emulsion layer contributes density at all wavelengths, the relative exposure of the emulsion layers may be altered to obtain considerable control of the sensitometric curve shape. This effect may be expected to be reasonably similar for other phototubes of the same response class if the deposit is silver but not if the deposit is dye.

Methods

Three of the more common methods whereby silver may be retained or recovered for use as a major component of the absorber are the resist, viscous bleach, and differential redevelopment.

The resist method requires that some material be applied to the sound area only, to prevent the action of the bleach upon the silver. The system has met with only limited success because of the numerous conditions that such a material must satisfy. Resists must not be soluble in the bleaching solution, must be pliable to avoid any possible cracking, and must prevent solutions from diffusing through the emulsion. In addition, a usable resist must be completely removable in the final processing solutions without affecting the dyes, or have characteristics which allow it to be retained on the film surface. If it is retained, it must be and remain similar to the emulsion material as to shrinkage, abrasion resistance and pliability. No material known at present adequately fulfills these requirements.

The viscous-bleach method retains the developed silver of the soundtrack area by the application of a bleaching solution to the picture area only. The silver record in the soundtrack area remains unaffected. There are several difficulties in this method. Bleaching must be accomplished in a shorter period of time than if conventional bleaching methods were used. The bleaching must be uniform and complete without the benefit of agitation. The evenness of the edge of the bleach application near the soundtrack must be very good or unpleasant random noise of high amplitude will be introduced and distortion of variable-area records increased by clipping modulation peaks. Inasmuch as this is a process requiring application of viscous solutions, the methods and materials found to improve redevelopment may be expected to improve viscous-bleach processing.

Differential redevelopment is a method whereby the silver in the soundtrack area produced in the initial development is reconverted to metallic silver after the bleach. Our experience has indicated this to be the most practical method.

Fig. 2. Spectral density of dye deposits of Eastman Color Print Film, Type 5382.

Developer Requirements

A soundtrack developer must have certain properties to obtain the desired dimensional and sensitometric requirements. In addition, the method of applying the developer to the film will place restrictions of its own upon the developer. A satisfactory developer must have chemical and physical stability as well as chemical and physical uniformity in order to maintain day-to-day process uniformity.

A bead or meniscus type of developer application requires that the developer be capable of uniform development without the benefit of agitation. Uniform development, therefore, is obtained by the use of a very powerful reducing agent capable of reducing to metallic silver any silver salt with which it comes in contact. A short induction period and high reaction rate are desirable so that the developer need be in contact with the emulsion for the shortest possible time in order to reduce the chance that vibrational forces may cause the developer to spread. In addition, penetration of the developer into the emulsion is a necessary requirement in order that it may reach all of the available silver salts. However, penetration is usually accompanied by an increased tendency for the developer to spread.

The maintenance of development within the prescribed limits requires that some material be added to reduce the tendency to spread beyond the area to which it is applied. Such materials, usually called thickening agents, can be used to control the spreading of the developer. The term "thickening agent" is misleading. "Coating aid" would be more descriptive, since viscosity alone is not a sufficient characteristic. Satisfactory materials are limited in number because of the requirements they

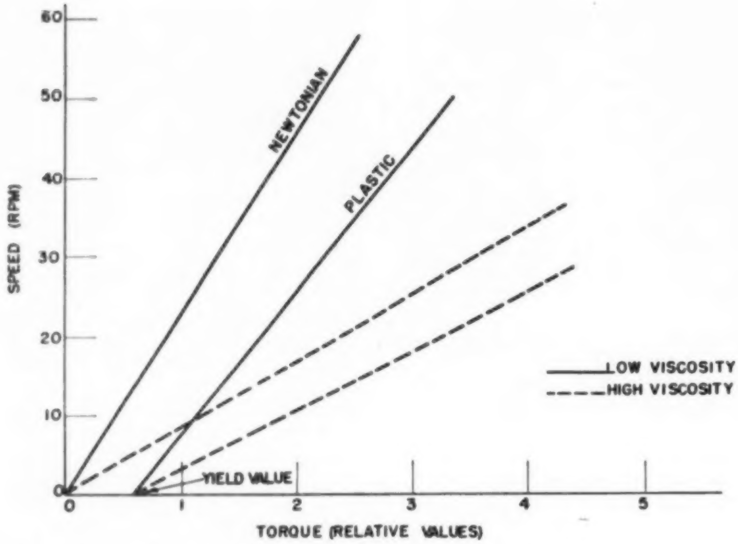

Fig. 3. Comparison of materials showing Newtonian and plastic flow characteristics.

must satisfy. They must be water soluble, since the developer is to be washed off the film at the end of the reaction period. They must be stable in solution at the very high pH which is necessary to satisfy the development requirements, and it is desirable that they also be stable in water solution for stock solution use. It is very desirable that these materials have a high yield value. Yield value, which is a distinguishing property of certain plastic materials, is the characteristic that is most indicative of the usefulness of any coating aid in a developer of this type. Viscosities of Newtonian liquids measured with a rotational type of viscometer will have a torque-speed curve which passes through the origin. Plastic materials have curves which intersect the torque axis at some point other than the origin (Fig. 3). This point is called the yield value of the material. This value indicates that some definite amount of force must be applied to the material when it is at rest to cause it to flow. While viscosity indicates a resistance to flow, the existence of a yield value indicates a resistance to the start of flow. A high viscosity will reduce the rate of spreading so that if the developer is removed soon enough after application, the spreading can be kept within reasonable limits. On the other hand, the length of time and viscosity are not as critical with a material having a high yield value, since the rate of flow is not the controlling factor.

Practical Examples

An example of a typical developer which has been designed to meet the given requirements is the one used in the Eastman Color Print process to develop soundtracks on Eastman Color Print Film, Type 5382.

Sound Developer SD-33 for Eastman Color Print Films.

Part A:

(1) Wet 1 gram of PVM* with 25 ml isopropyl alcohol in a 50-ml beaker.
(2) Place 390 ml distilled water in a 500-ml beaker.
(3) Add the PVM* and alcohol to the water. Agitate vigorously while adding.
(4) Discard any material that remains in the 50-ml beaker.

Part B:

565 ml distilled water
60 grams sodium sulfite (Na_2SO_3)
80 grams sodium hydroxide (NaOH) — flakes

Cool and add 60 grams hydroquinone (HQ)

Add Part A to Part B. Add 20 ml ethylene diamine.

Surface drying is very important to successful application of any sound developer since all developers contain water soluble materials and therefore have some tendency to spread in the presence of surface moisture. The PVM coating aid is very good in this respect but the need for proper surface preparation is not eliminated. Although the moisture content of the film is not critical, surface moisture should be completely removed but the film should not be dried too greatly (as in a drying cabinet) or the increased hardness will impede penetration. A satisfactory method of removing surface moisture is discussed more fully in another publication.[3]

Three common methods for applying a sound developer to the film are meniscus, extrusion and roller application. The method selected for the most intensive investigation by the Eastman Kodak Co. involved the use of a roller applicator.

Some additional factors which affect application with the use of roller applicators are the direction of rotation of the coating wheel, the rate of rotation and the spacing between the wheel and film. Experience indicates that the preferred direction of rotation is such as to oppose the direction of the film. There is a tendency to form a more uniform coating when this direction of rotation is used. The speed of the coating wheel is dependent upon the film velocity, the direction of rotation and the viscosity of the developer.

The final wash for the removal of the developer should be a flat jet spray nearly perpendicular to the direction of film travel or inclined slightly in the direction of film travel. Quite satisfactory basic flat jet spray nozzles are commercially available.

A number of laboratories using a roller application method have experienced such difficulties as random spreading, spreading as some function of film hardness due to exposure or processing conditions, and severe spreading at every splice. When the developer SD-33 is used with a properly adjusted applicator and adequate surface drying these defects are eliminated except for slight widening at splices. This widening is due only to the decreased separation between the film and the coating wheel.

*PVM: The half amide of the copolymer of methyl vinyl ether and maleic anhydride. (General Aniline and Film, PVM/MA.HA. Type 30.) Individual circumstances may require up to 5 grams per liter. If more than 10 grams appears necessary, the material is probably not Type 30.

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High-Efficiency Air Squeegee and Soundtrack Developer Applicator for Color Films

By HOWARD F. OTT and ROBERT C. LOVICK

A soundtrack developer applicator of the roller type is described. It gives soundtracks of high quality and operates from the lowest practical processing-machine film speeds to over 340 fpm. Design features are discussed. Important to success of the applicator is a highly efficient squeegee which is described in detail.

A LITTLE MORE THAN a year ago the need arose in the Color Technology Div. of the Eastman Kodak Co. for a new applicator for experimental work in applying soundtrack developer to Eastman Color Print Film. Previous applicators had not been entirely satisfactory with film speeds as high as 200 fpm, either because the processing solution would spread beyond the soundtrack area or because the solution could not be applied uniformly enough to the desired area. It was desired to demonstrate that the roller applicator principle was useful at the higher film speeds. Rather than copy the better features of the existing applicators, it was decided to use only their general form and to design a new applicator which would meet all the known requirements for satisfactory soundtrack processing. The applicator must:

(1) Meet ASA standards and tolerances on the position and width of the applied developer strip.

(2) Produce a strip free from waviness.

(3) Allow for considerable variation in the amount of solution applied.

(4) Apply solution at a uniform rate at any setting.

(5) Allow for considerable variation in processing time.

(6) Wash solutions from film so that the unprocessed areas are unaffected by developer.

(7) Pass film splices.

Figure 1 shows a schematic diagram of the applicator. The film proceeds from a wash tank through an air squeegee and into a dry tank. From the dry tank the film moves over an idler roller which feeds it to the first positioning roller, then on to the backup roller. Here the rotating applicator wheel, the lower side of which dips into the tank of developer solution, deposits the processing solution on the film. The applicator wheel rotates clockwise, carrying solution to the film in a direction opposite to the film's travel. The dial indicator reads directly, in thousandths of an inch, the spacing between the surface of the applicator wheel and the surface of the film. An eccentric provides easy adjustment for this spacing. Processing takes place as the film moves under the second positioning roller and over two more idler rollers and is stopped when jets of water wash the applied solution from the film.

In order to meet the ASA standard on width of the strip, the applicator wheel was ground to exactly the desired width, and meniscus spreading was prevented by painting the sides of the wheel with nonwetting Teflon paint. However, the solution will spread if the wheel carries too much solution for the limited space between the applicator and the film or if the wheel is rotating too fast for the speed of the film. The spacing is, therefore, generally set at approximately five thousandths of an inch, and the speed of rotation of the applicator wheel, determined by experience, is set so that the proper amount of solution is applied to the film. Figure 2 shows the effect of the amount of developer carried to the film. Note the narrow and irregular strip at the right indicating insufficient developer; the uniform strip at the center, correctly processed; and the wide but less regular strip at the left indicating too much developer. The position of the strip of applied developer on the film is controlled by the two positioning rollers which have flanges carefully cut to run true and to fit the film closely. Each roller is on a spring-loaded bearing to eliminate the possibility of end-play and is adjustable to eliminate expensive machining operations and to provide for readjustment in case of wear or repair.

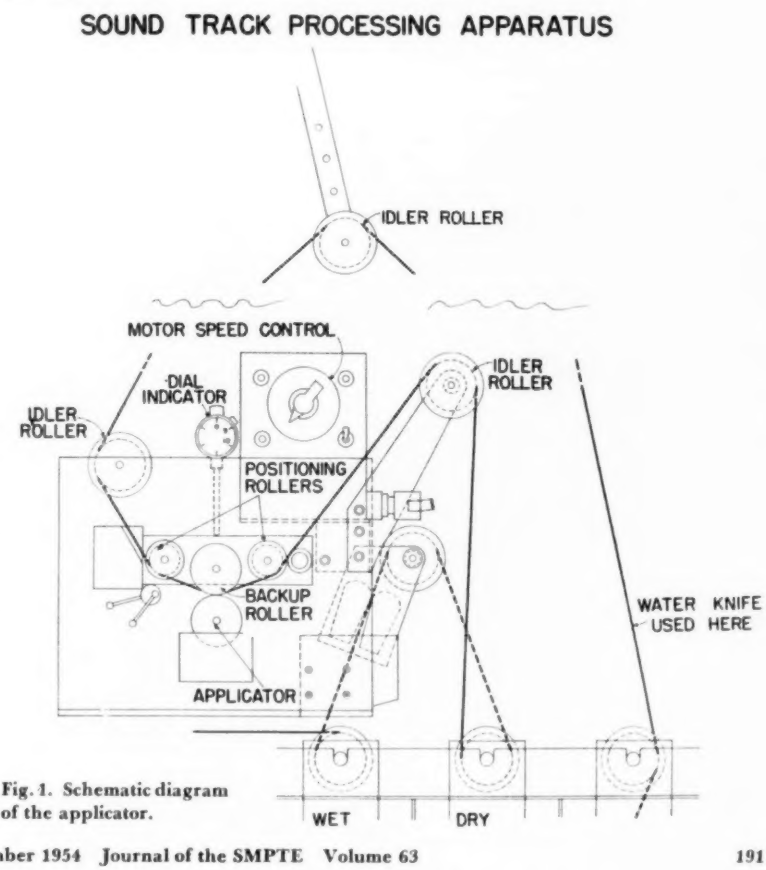

Fig. 1. Schematic diagram of the applicator.

Presented on May 4, 1954, at the Society's Convention at Washington, D.C., by Howard F. Ott (who read the paper) and Robert C. Lovick, Color Technology Div., Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on June 25, 1954.)

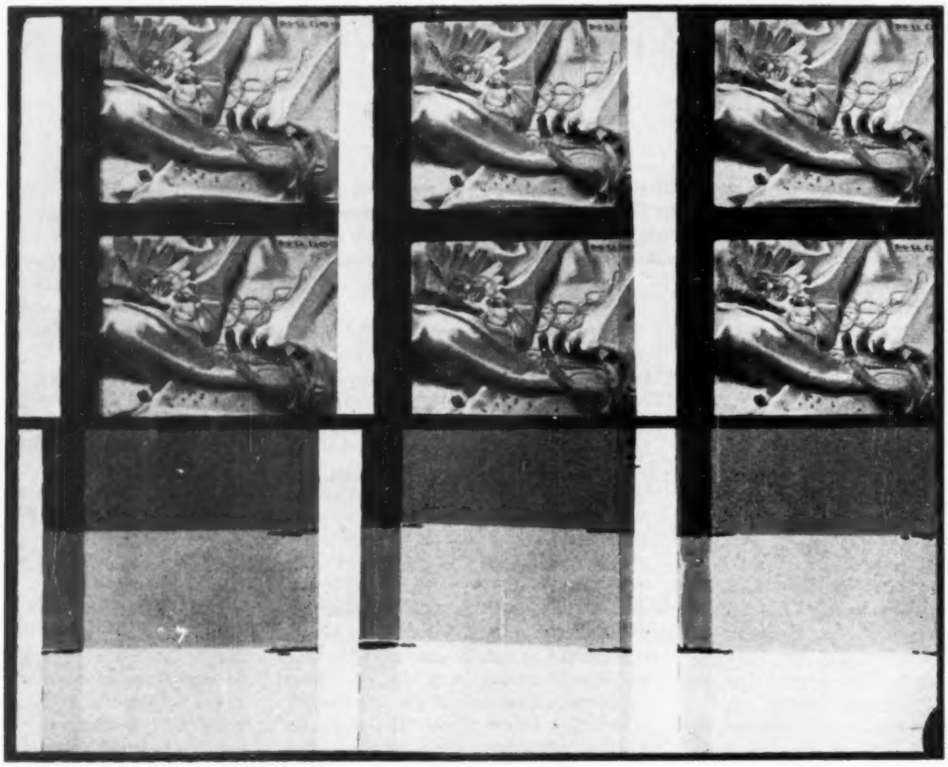

Fig. 2. Effects of applying various amounts of developer: left, too much developer; center, the correct amount; right, too little developer.

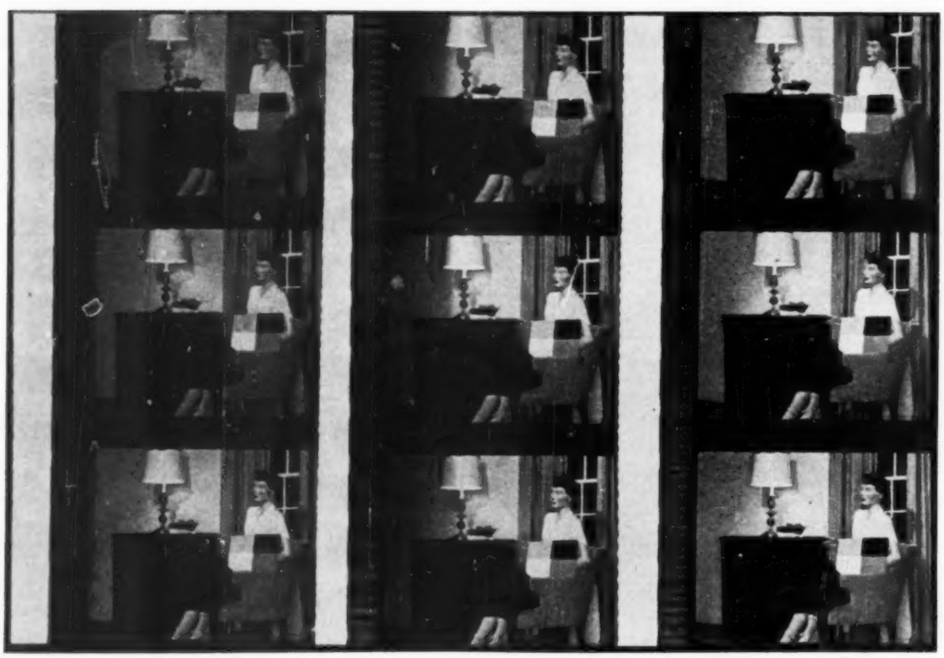

Fig. 3. Effects of moisture present on the film at the time of application of the soundtrack developer: left, droplets of water; center, overall surface moisture; right, surface dried.

In controlling the width of the strip, it is of utmost importance that all surface moisture be removed from the film. Application of solution on film with overall surface moisture leaves poorly defined edges and water droplets cause uneven spreading of the processing solutions. Figure 3 shows the effects produced by moisture on the film. The air squeegee mentioned earlier is used for removing all the surface moisture and will be described in detail later in this paper. The dry tank was reserved for additional drying. This was found unnecessary but the film is threaded through it as a matter of convenience.

The second requirement for the applicator—that of preventing wavy edges—is closely associated with that of controlling the width of the strip. The controls described earlier also help meet this requirement. To eliminate waviness due to variations in the space between the applicator wheel and the film, the wheel and backup roller have been supplied with extreme precision bearings and were made so that the peripheries of both run perfectly true. To avoid variations in the speed of the applicator wheel, a good motor for the drive unit was selected, the drive for the wheel was made with considerable care, and the wheel was made as massive as space would allow.

The third requirement is for a wide variation in the amount of solution applied. In addition to control by the inclusion of a thickening agent in the solution, the speed of the applicator wheel is readily adjustable. For this purpose a General Radio Motor Speed Controller is used in combination with a 115-v d-c Bodine Shunt Motor with a speed reducer geared 10:1. In an experiment to determine if roller application was usable at high film speeds, a good quality application was made at a film speed of 340 fpm, the limit of the film-conveying equipment. Satisfactory operation can be obtained at a speed as low as 10 fpm. At 25 fpm, good results are obtained with the applicator wheel speed set at approximately 70 rpm.

The provisions described so far also helped in meeting the fourth requirement—uniform rate of application. The applicator has an overflow reservoir to make possible accurate control of the depth to which the applicator dips into the solution. This was found unnecessary for most of the work because the sides of the wheel do not wet appreciably. The depth of the wheel in the developer solution is relatively unimportant in gauging the quantity of developer carried. For experimental purposes it was found more convenient to add periodically to the developer in the tank than to set up the overflow tank with a supply and feed system.

Processing time is determined by the film speed and by the length of the film path between the point of application and the jet wash, and can be varied over a wide range by changing this path as desired. The final idler roller (located above the applicator mechanism) can be mounted at any desired height on a mount bar drilled for this purpose. This variability is required in order to obtain the proper development time for the speed at which the film is moving; that is, the higher the film speed, the longer the path required.

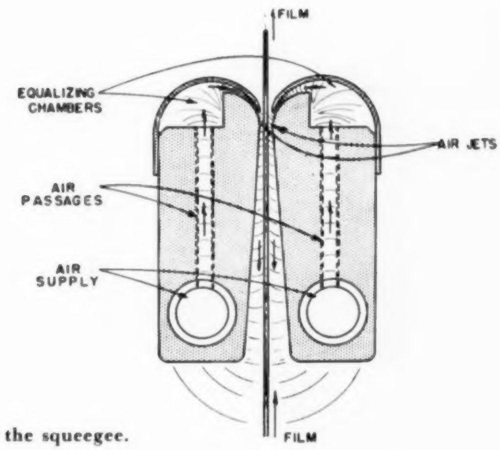

Fig. 4. Schematic diagram of the squeegee.

After application of the soundtrack, the film is washed in a tank with a constant water spray. Immediately preceding this tank, jets of water are directed diagonally downward on both sides of the film in such a way that the developer is carried off the film on the soundtrack side.

Splices pass through easily. Referring again to Fig. 1, it can be seen that the backup roller and the two guide rollers are mounted on a single hinged arm. A splice approaching the limited space between the backup roller and the applicator wheel forces the arm to rise. When the splice has passed through, a spring returns the arm. To maintain accuracy of setting, the arm is mounted with spring tension against ground locating surfaces on the main applicator support.

The Squeegee

Earlier it was pointed out that removing surface moisture from the film was of the greatest importance for good quality soundtrack application. For that reason the air squeegee will be described in detail. Besides contributing substantially to the success of this application system, the squeegee is useful for removing moisture from film wherever a moisture problem exists. Figure 4 shows a schematic diagram of the squeegee. The wet film moving toward the squeegee enters the space between the two symmetrical halves of the unit. Here the largest drops are blown off by the air following along the film from the jets. Gradually, as the film approaches the jets, more and more water is removed from the film until at the throat — the point where the film is closest to the face of the squeegee — the air velocity is great enough to carry off all surface moisture. In normal use, film approaching the squeegee is coming out of a wash tank and moving upward. It is usually most convenient, therefore, to mount the squeegee just outside the tank so that the water removed from the film will be returned to the tank.

Figure 5 shows performance characteristics of the squeegee at various adjustments and air pressures. Critical film speed is defined as that speed below which all surface moisture is removed, leaving the film tacky. Adjustments are not particularly critical and even at only 5-lb pressure the critical film speed is about 50 fpm for normal operation. With higher air pressures, substantially higher film speeds can be used. Generally the squeegee is used at 10–20 lb depending on the film speed in the machine; however, it has been used in tests at 60 lb. At 10-lb air pressure the squeegee consumes about 8 cu ft of air per minute; at 15 lb about $11\frac{1}{2}$ cu ft per minute; at higher pressures proportionately more.

The question may arise as to whether the film can be damaged because of the close clearances and high air velocity of the squeegee. The air forms a cushioning bearing on which the film floats through the unit and no film has ever been damaged by the squeegee. Film damage is possible, however, if the air is not turned on or if the squeegee is mounted out of line.

In the latest model squeegee there is one air connection from which air is distributed in the support block to two hollow posts. These support the two squeegee bodies and feed air to them. The air then flows through holes in the bodies to distribution chambers behind the blades, then out through the jets. The support, which is rigidly fastened to the support block, has at the lower end provision for an adjustable

left, droplets of water; center, overall surface moisture; right, surface dried.

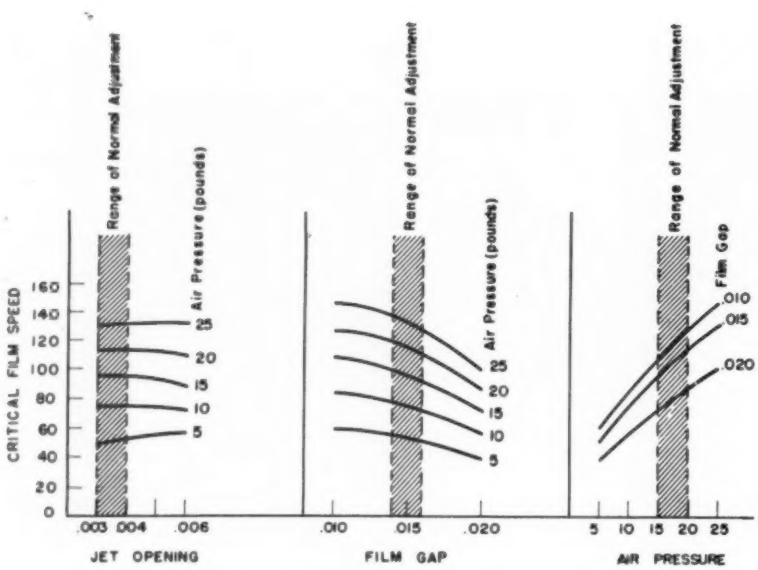

Fig. 5. Performance characteristics of the squeegee.

connection to the support arm. The other end, adjacent to the jet end of the squeegee, supports two double cams. Two pins, one in each of the two squeegee bodies, engage the cams. One cam has a small handle used for opening the unit for film loading, out-of-use position, cleaning, etc. The handle opens both halves symmetrically to free the film path. The other cam is adjustable, and when clamped in adjusted position maintains the clearance through which the film passes. A spring connected between two other pins, one on each of the body blocks, keeps the unit closed except when intentionally opened or when a splice passes through.

Eyelet, staple and tape splices have been passed through both the applicator and the squeegee without damage, but it is possible for metallic splices to damage the equipment and much time has been spent in seeking a good temporary splice. One processing machine has been equipped with an automatic stitch splicer which is described in detail in the paper below. This splice will cause no damage, and in normal use no other type of splice is put through the applicator. No special precautions have been taken with the squeegee, however, and when it is used only for removing surface moisture prior to final drying of the film, the squeegee has successfully handled whatever type of splice was currently being used with the machine on which it was installed.

Conclusions

With this apparatus, soundtracks of high quality have been produced. It has been demonstrated that it is possible to use the roller applicator method at high film speeds. Further, it has been shown that the success of the method depends largely on the design and construction of the equipment, with particular emphasis on the film squeegee.

Discussion

Carl F. Turvey (*Dept. of Agriculture*): What type of air compressor is used in supplying air for the squeegee?

Mr. Ott: We have a large compressed-air system which supplies most of Kodak Park and we're simply using that system. We are filtering it, however; we're using a Dollinger Staynew Air Filter, so that the fine openings in the jets do not become clogged.

Mr. Turvey: It looks as though the emulsion of the film is coming in contact with the rollers, shown in the diagram. Is that correct or not?

Mr. Ott: The emulsion comes in contact with one idler roller at the extreme edges only before application, and we've had no trouble whatsoever from that. It doesn't contact the rollers at all afterwards.

A Rapid Automatic Stitch Splicer for Darkroom Operation

By DUANE E. GRANT and HOWARD F. OTT

A Pfaff "zig-zag" type sewing machine has been used in the development of an automatic stitch splicer for splicing 35mm film before processing. The complete splicing operation can be done quickly and easily in the dark with a minimum of operator training. The splice, made with nylon thread, has several features not found in tape, staple and heat splices. Most important are strength with flexibility, no effect from solutions or softening of film, and no damage to equipment used on the processing machine.

During investigation of the application of developer to film soundtrack, the need became evident for a splice which could not damage processing equipment. The eyelet splice in use on the experimental processing machine in the Color Technology Division of the Eastman Kodak Co. was such that it could damage the applicator roller used in soundtrack processing. In addition, there were other disadvantages: it was thick at the eyelet, relatively weak, and was subject to attack by solutions. An eyelet splice which was allowed to remain in a hypo or bleach tank overnight dissolved completely. Other types of splices, such as tape, staple and heat splices, have been considered, but none was entirely satisfactory for one reason or another. A zig-zag sewed splice using nylon thread seemed attractive because the resulting splice was thin and not subject to attack by processing solutions. Furthermore, the zig-zag nature of the splice provided a satisfactory separation between stitch perforations which prevented weakening of the film along the stitched path.

Presented on May 4, 1954, at the Society's Convention at Washington, D.C., by Duane E. Grant (who read the paper) and Howard F. Ott, Color Technology Div., Eastman Kodak Co., Rochester 4, N.Y.

(This paper was first received on June 25, 1954, and in revised form on October 19, 1954.)

Requirements

The requirements for a satisfactory stitch splicer and sewed splice are as follows:

1. The operator must be able to make a splice in the dark with complete ease and safety and with a minimum of training.
2. Operation of the splicer must be nearly automatic to reduce the number of steps required in making a splice.
3. The entire sequence of steps required should take less time than other methods in use.
4. Film perforations at the splice should be aligned so that the splice can be driven by a sprocket drive.
5. The splice must be incapable of damaging equipment.
6. The resulting splice must have sufficient points sewed together to be strong, yet the needle perforations must be kept separated and to a minimum to avoid the possibility of film breaks where sewed.
7. The thread must not be affected by solutions used in the photographic processes.
8. The splice must be flexible enough to pass easily over rollers used in the processing equipment.
9. Softening of gelatin layers and film backing must have no effect on the quality of the stitched splice.
10. The width of the splice must be the same as that of the unspliced film.

In Figure 1 the 35mm stitch splicer is shown installed on the experimental processing machine. The head unit of a Pfaff, Model 130, sewing machine was used in its construction. This model has standard features found on most straight-stitch, household sewing machines and, in addition, has an adjustable mechanism which produces a zigzag stitch.

Changes Made to the Sewing Machine

In order to convert the Pfaff head to a machine that would fulfill the above requirements, the following changes were made:

1. The feeder mechanism was replaced by a carriage assembly and an intermittent drive mechanism. Mounted on the bed plate of the machine, the carriage assembly holds the film to be sewed. The path sewed is controlled by a rectangular gear mounted on the carriage assembly and actuated from below by the intermittent drive mechanism. The film holder has one locating pin and two guide bars to align the film for sewing. The space between the two guide bars serves as a measurement for correct film overlap. The pattern obtained with the stitch splicer is shown in Fig. 2. The intermittent drive mechanism shown in Fig. 3 is powered by the same shaft that rotates the sewing machine hook. An intermittent drive was necessary since the film holder can move only when the needle is out of the work.
2. The presser-foot shoe was changed to one of better shape for sewing zigzag in both directions. Also a stop was provided to keep the foot off the film during sewing to allow freedom in pulling the thread tight at the stitch.
3. The presser-foot lever was replaced by a cam with a solenoid hold-down and spring return.
4. The series motor was replaced by an induction type so that an a-c, motor-stopping circuit could be used.* A cam mounted on the balance wheel operates a set of breaker points which stop the motor when the take-up lever is properly positioned. This makes it possible to stop the machine with the needle out of the work in a position to be ready for sewing, without de-threading the needle. As an additional safeguard, since the splicer is to operate in the dark, a "needle-down" buzzer is incorporated to warn the operator if the motor-stopping mechanism should fail and the needle has stopped in the film.
5. Automatic switching was provided so that a foot-operated switch would initiate the complete splicing cycle.
6. A spool pin adapter was made to accommodate large commercial-size spools.

* G. H. Dawson and H. F. Ott, *Rev. Sci. Instr.*, 25: 828 (1954).

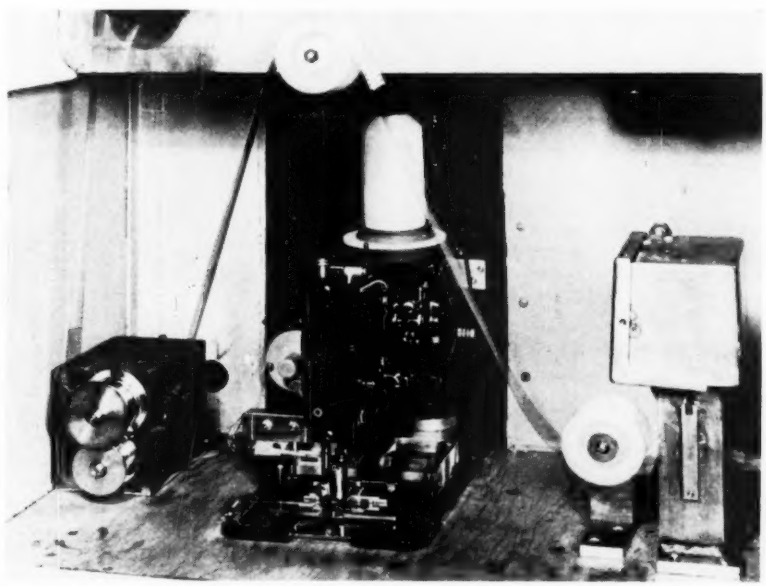

Fig. 1. 35mm stitch splicer installed on processing machine.

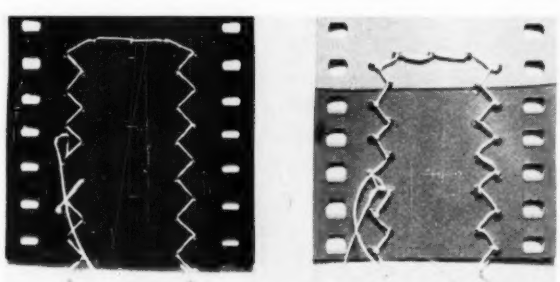

Fig. 2. 35mm sewed splice.

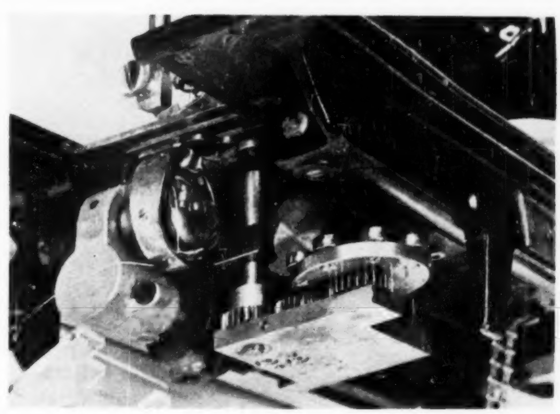

Fig. 3. Drive mechanism for 35mm stitch splicer.

7. The bobbin winder was removed and rebuilt as a separate unit using the motor originally on the machine.

A description of the steps involved in making a splice will show how some of the special design features are related to the operation of the splicer. The operator first positions the film on the film holder using the guide bars and the locating pin to obtain the proper overlap and alignment. He next depresses a foot switch. A rectangular path is sewed automatically, at the end of which the machine stops, needle up, ready for the next splice. The film is removed, trailing threads cut, and the spliced film is placed on a by-pass roller. This short procedure compares favorably with procedures required on other types of splicers.

Safety features as well as mechanical features have been considered in the development of the splicer. A guard is provided around the needle to prevent "sewed" fingers. It is pivoted so that it can be swung to one side while threading or replacing the needle. All moving parts such as the drive mechanism, carriage assembly and solenoid hold-down for the presser foot have protective covers. The entire splicer is grounded to prevent electrical shock.

Conclusion

So far as we know, this is the first application of zig-zag splicing to 35mm film. It is not the only method, however, which can be used to arrive at the same end result. While the use of a zig-zag type machine is considered important to the success of this splice, various mechanical arrangements and operations are possible. The splicer described in this paper does work well and fulfills the earlier mentioned requirements. Since its installation eight months ago, there has not been one case of a break at a sewed splice. It is possible to rerun old splices in rolls of leader until it is desired to remove sections containing many splices; no weakening of the sewed splice has been observed.

Discussion

Carl F. Turvey (Motion Picture Service, U.S. Dept. of Agriculture): Do these perforations maintain their registration throughout the time it takes to run through a developing machine?

Mr. Grant: Yes, we have had no difficulty. The perforations do maintain alignment.

Saul Jeffe (Movielab Film Labs, Inc.): Can you tell us how long the splice holds up in the developer, bleach or the hypo?

Mr. Grant: Since our use of this splice on the experimental processing machine at Kodak Park, we have not had a single break at a sewed splice. As for holding up, the splice has been used for leader since the splicer's installation almost a year ago and it has never been found necessary to replace any of the splices. Splices in leader have been rerun through the machine over and over again.

Anon: Is it possible to use this splice on a sprocket-drive machine?

Mr. Grant: Yes, it is. As pointed out, one of the advantages of this splice is that sprocket-type drives can be used.

A 16mm Projector for Research Films

By S. A. WEINBERG, J. S. WATSON, and G. H. RAMSEY

To obtain maximum information from rapid serial studies of living subjects, the films should be viewed both in slow motion and as stills. This requires special projection apparatus. Alterations carried out on a Kodak "Analyst" projector make possible tolerably flicker-free projection at speeds between 15 and 6 frames/sec and also pushbutton controlled single-frame operation, either forward or reverse. Change-over from continuous to single-frame operation can be made quickly, without manual adjustment of focus or illumination.

In studying rapid serial photographs, the question may arise whether it is worth going to the touble of projecting them as motion pictures. After all, the action has already been analyzed on the films; why bother to synthesize it again? The ideal way of viewing would seem to be frame by frame, making paper enlargements where necessary, so that each picture can be compared side by side with the others.

This argument may be valid in some fields; but in reading x-ray motion studies of living subjects[1] we have found that preliminary viewing by motion-picture projection is a great elucidator and time saver. It is much easier to pick up the complex rhythms of action when they are seen, so to speak, in the perspective of motion, than to try to do it by tabulating frame-to-frame displacements. Furthermore, no matter how sharp and detailed the separate pictures may appear to be, additional details are almost always revealed when the pictures are projected in motion. These cannot possibly be located on individual frames except by constant reference to the moving film.

The hidden structural detail made perceptible by projection should not be confused with "historical" detail missed from the film record because of too slow a rate of exposure. Projection can hardly restore events which were not photographed. The "historian" will have to interpolate them out of his head, or, better, retake the pictures at higher frequencies.

Serial pictures on standard motion-picture film offer no projection problems, and are generally screened anway, if only out of curiosity; those exposed on outsized films, or by some of the outlandish methods of high-speed photography, first have to be rephotographed with as good registration as the circumstances allow. So long as the resulting motion picture is no unsteadier than television, the modern observer should be able to view it with equanimity.

Viewing is made easier and more informative by the right sort of projection apparatus. The projector for this work should have the flexibility of an editing machine but with better definition and more light intensity. What is wanted is to be able to run the film in either direction at any desired speed from 1 to 16 frames/sec, and to be able to change expeditiously from continuous to single-frame projection and back again. The majority of 16mm silent projectors are provided with a clutch for stopping on the film and are quite flexible so far as speed regulation is concerned. Unfortunately, as soon as speed falls below about 14 frames/sec, the fire shutter drops, and screen illumination immediately becomes very dim. Doctoring the shutter to stay up at slower speeds is not recommended, since the shutter may fail to drop when the projector is stopped on a frame, in which case the frame burns. Furthermore, with full screen illumination, flicker tends to become intolerable at the slower projection speeds. About the best that can be done is to reduce the throw to around 4 ft, let the fire shutter stay down, and, when single framing, disconnect the

A contribution submitted on August 1, 1954, by S. A. Weinberg, Dept. of Radiology, University of Rochester School of Medicine and Dentistry, Rochester 20, N.Y. This project was supported in part by a research grant from the National Heart Institute of the National Institutes of Health, U.S. Public Health Service.

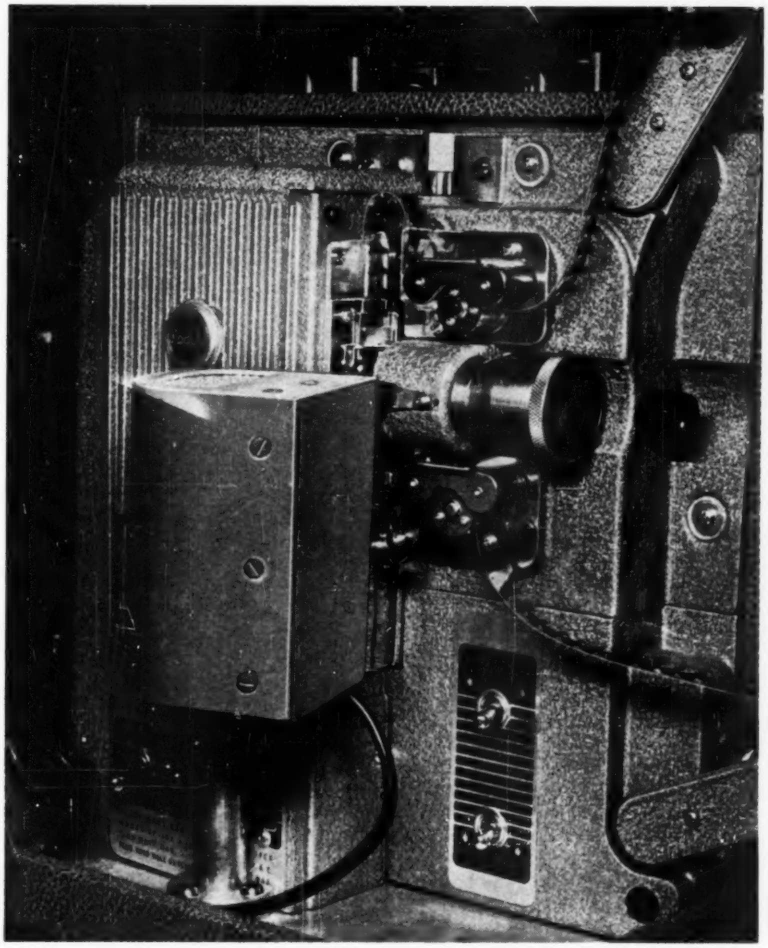

Fig. 1. Modified Analyst projector. Note extra blower for cooling the far side of the film. Speed control lever is at extreme left.

clutch, speed up the fan, and turn the mechanism by hand. But this does not solve the problem of slow speed flicker.

Our first attempt to devise a special projection apparatus was not very satisfactory. We acquired a 16mm projector of the type having a right-angle prism between the lamp and the condenser, and placed in it a lamp of low wattage. Another right-angle prism was

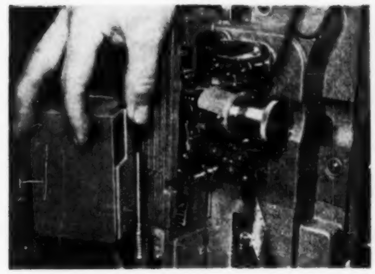

Fig. 2. Blower housing held out of the way for threading.

used to reflect the film image downward on a horizontal drawing board. The motor was disconnected from the drive shaft so that the fan would run at constant speed, and the mechanism was hand cranked either forward or backward at a 7 to 1 ratio. The principal troubles were poor registration, change of focus, and flicker.

Our second, more successful attempt consisted of alterations to the Kodak "Analyst" projector shown in Fig. 1. This machine is much used by athletic coaches for post-mortems on football games and similar contests. Standard features of the Analyst are: a separate motor for the cooling fan, heat-absorbing glass between the condenser and film, heat-absorbing coating of the condenser lenses, a speed selector giving a choice between 16 and 24 frames/sec, and an instantly reversible drive motor. The standard Analyst has no provision for single framing and hence needs no fire shutter; the heat absorbing glass and coatings take care of the momentary arrest of the film when the motor is reversed.

Like most silent 16mm projectors the Analyst has a three-blade shutter which interrupts screen illumination 48 times per second at the standard silent projection speed of 16. Whether flicker will be noted at this frequency will depend

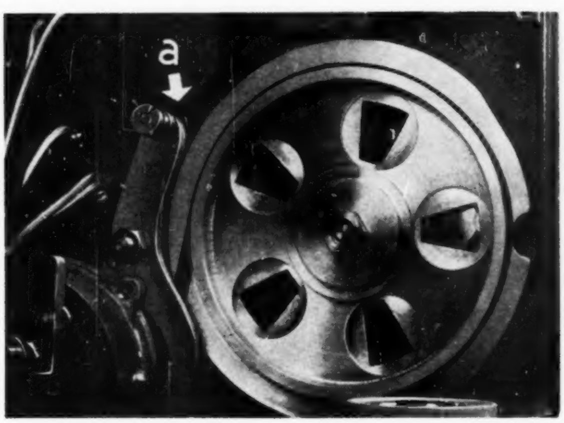

Fig. 3. Five blade shutter seen from the rear. Lamp and lamphouse have been removed. Clutch idler "a" rides on shutter rim. Half moon recess and ramps can be seen on opposite side.

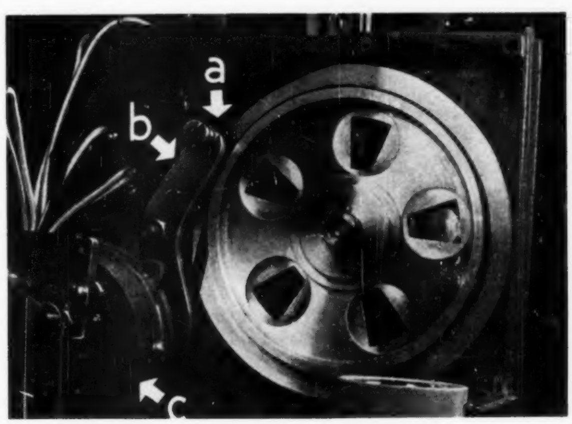

Fig. 4. Clutch idler "a" is seated in recess in shutter rim. Geared-down motor "c" actuates clutch arm "b," releasing clutch for one shutter revolution.

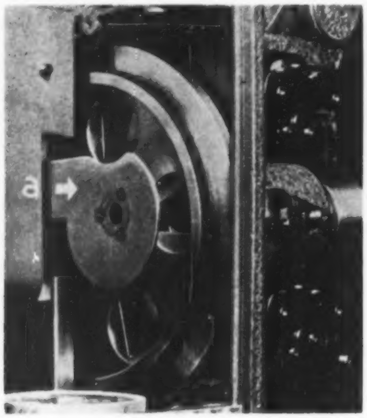

Fig. 5. Moveable diaphragm "a" centered in optical axis for single frame operation of projector.

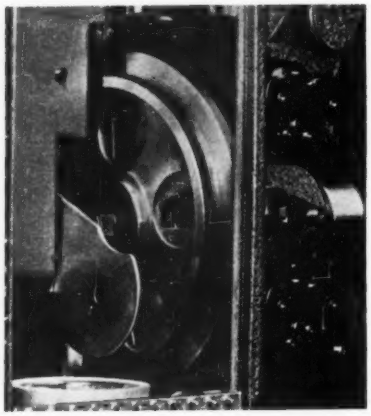

Fig. 6. Diaphragm displaced, allowing full illumination for continuous projection.

mainly on the intensity of the intermittent illumination.[2] Thus, if screen brightness is increased beyond the usual 10 to 14 footlamberts, or if the print being shown has unusually large highlight areas, a more or less gentle ripple will be perceptible to the average healthy observer.[3] Slowing the projector will naturally make the ripple more conspicuous. However, the student of research films has learned not to be distracted by ripple, nor even by frank pulsation, so long as it does not interfere with his perception of detail. The limit seems to be reached, for most observers, when the rate of intermittence has been slowed to about 60% of fusion frequency for the particular screen area being studied. With a three-blade shutter this means a "minimum tolerable projection speed" in the neighborhood of 10 frames/sec, with a four-blade shutter, in the neighborhood of 7.5, etc.

Experimental shutters having four, five and six blades were fitted to the Analyst, together with matching pull-down cams furnished by Eastman Kodak Co. The five-blade shutter which was finally chosen has the advantage of not requiring too drastic a pull-down cam, while at the same time permitting a 40% reduction of projection speed. As a result of the shutter alteration, so-called flicker-free projection speed becomes 9.6 instead of 16, and minimum tolerable speed becomes 6 instead of 10, thus somewhat narrowing the wide gap between continuous and single-frame operation.

The indexing clutch designed for the Analyst makes use of the outer rim of the new shutter as a bearing surface for the clutch idler shown at "a" in Fig. 3. On the right edge of the shutter can be seen the conventional half-moon recess in which the idler seats itself while the film is at rest. On either side of the recess are short ramps which act through the clutch arm linkage to open the drive-motor circuit just before the idler falls into place. The film can be advanced one frame at a time in either direction by touching a pushbutton which starts the small, geared-down motor seen at "c" in Fig. 4. This in turn lifts the clutch arm and closes the drive-motor circuit for one revolution, the small motor meanwhile shutting itself off again by means of a cam-actuated limit switch.

The speed control lever is located on the rear of the projector and is just visible at the extreme left of Fig. 1. The uppermost position of the lever brings the clutch idler into contact with the shutter rim for single framing, and also connects the drive motor with a Lee governor, set for about three shutter revolutions per second. The second lever position is transitional in that the drive motor is still connected with the Lee governor, but the indexing clutch is no longer operative. The third lever position disconnects the governor and cuts in a rheostat, making possible a choice of speeds from 5 to 15. The fourth position cuts out the rheostat and lets the projector run at a constant speed of 15.

During single-frame operation, a diaphragm is automatically positioned between the condenser and the shutter, balancing single-frame illumination with the intermittent illumination of the running projector as illustrated in Figs. 5 and 6. This system, suggested by Eastman Kodak Co., also increases the depth of focus of the projection lens during single framing and thus counteracts the tendency of the stopped film to go out of focus. An extra blower, shown in Figs. 1 and 2, cools the side of the film away from the lamp and makes it possible to stop on a frame indefinitely.

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2. S. Hecht and C. D. Verrijp, "Influence of intensity, color, and retinal location on the fusion frequency of intermittent illumination," *Proc. Nat. Acad. Sci., 19:* 522, 1933.
3. N. Enzer, E. Simonson and S. Blackstein, "Fatigue of patients with circulatory insufficiency investigated by means of the fusion frequency of flicker," *Ann. Int. Med., 16:* 701, Apr. 1942.

News and Reports

Society Election and Business Meeting

The ballots were counted in Los Angeles on October 16, with the following results reported to the Membership during the 76th Convention Get-Together Luncheon on October 18. The following will serve for two years beginning January 1, 1955.

John G. Frayne, President
Barton Kreuzer, Executive Vice-President
Norwood L. Simmons, Editorial Vice-President
Byron Roudabush, Convention Vice-President
Edward S. Seeley, Secretary
Gordon A. Chambers, Governor, East
John W. Duvall, Governor, West
Lloyd T. Goldsmith, Governor, West
George Lewin, Governor, East
W. Lozier, Governor, Central
Malcolm G. Townsley, Governor, Central

(Election of Barton Kreuzer as Executive Vice-President creates a one-year vacancy for Financial Vice-President, an office to which Mr. Kreuzer was elected a year ago. His successor will be appointed by the Board of Governors in accordance with the Bylaws.

The following Section officials have been elected, the Chairmen and Secretary-Treasurers for one-year terms and the Managers for two. The three Section Chairmen, by virtue of office, also serve one-year terms as Society Governors.

Atlantic Coast Section
Everett Miller, Chairman
G. H. Gordon, Secretary-Treasurer
K. M. MacIlvain, Manager
W. H. Deacy, Manager
V. M. Salter, Manager

Central Section
J. L. Wassell, Chairman
K. M. Mason, Secretary-Treasurer
R. G. Herbst, Manager
J. C. Diebold, Manager
D. W. Ridgway, Manager

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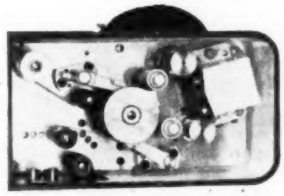

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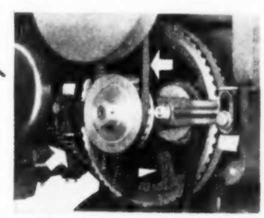

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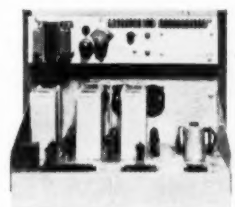

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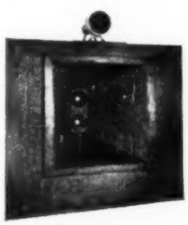

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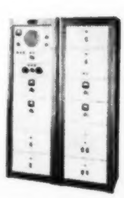

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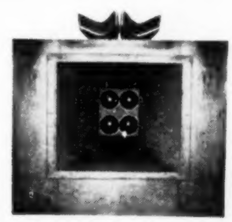

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Pacific Coast Section
P. G. Caldwell, Chairman
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R. G. Hufford, Manager
Karl Freund, Manager
L. H. Bowman, Manager

The Annual Business Meeting of the Society on Monday, October 18, discussed and approved the proposed increases in membership fees to make them as follows:

Fellows and Active Members, $18.00
Associate Members, $12.00
Student Members (not changed), $5.00

The Board's considerations leading the Resolution for amending the Society's Bylaws were reported in the September *Journal*.

Education, Films and TV

As described in the August 1953 *Journal*, the **Rochester Institute of Technology** has for some time been working on plans to offer a degree program in its Department of Photography. These plans have now matured and beginning with the fall quarter it will be possible for students at the Institute to work toward the Bachelor of Science degree in photography. The new plan provides for the well established Associate in Applied Science degree program to be the basic educational program for the first two or three years of study. The BS program is built directly on top of the AAS plan and requires one or two additional years of study, depending upon the student's major course of study.

The second annual **American Film Assembly,** sponsored by the Film Council of America, will be held April 4–9, 1955, at the Waldorf-Astoria Hotel, New York. At the April 1954 Assembly some 360 16mm films were exhibited in 26 screening sessions, and attendance was over 1000. Climaxing the three-day affair were the Golden Reel Awards presented to the 12 films receiving the highest score in achievement of purpose in their respective categories.

The National Planning Committee of the American Film Assembly held regional meetings in Hollywood, New York and Evanston during the early summer. At these meetings and by subsequent correspondence the rules for the 1955 program were given detailed consideration. Now in the last stages of preparation, the Regulations and Procedures along with the Golden Reel Film Festival entry blanks will be in the mail by the end of September. They are also available on request from American Film Assembly, Film Council of America, 600 Davis St., Evanston, Ill. Deadline for entry in the Festival competition is January 15, 1955.

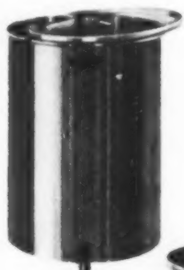
Rudy Bretz, Television Program and Production Consultant, author of several articles in this *Journal* and of the book *Techniques of Television Production* and coauthor of *The Television Program* and of *TV Scripts for Staging and Study*, has been named Production Consultant to the Alabama Educational Television Commission. The most progressive state in the union, as far as educational television is concerned, Alabama has under construction a three-station educational television network which will cover 90% of the state. The majority of this construction is financed by State funds, appropriated by the Alabama legislature. Mr. Bretz will oversee the design and construction of production facilities and take an active part in planning the programming of the network. Programming is expected to begin within the year.

Book Reviews

Television – The Electronics of Image Transmission in Color and Monochrome – 2d ed.

By V. K. Zworykin and G. A. Morton Published (1954) by John Wiley & Sons, 440 Fourth Ave., New York, 16 ix + 1037 pp., 698 illus. 6 × 9 in. Price $17.50.

The second edition of this book has expanded as has the subject with which it deals. In the fourteen years since the first edition, color, improved camera tubes, video tape recording, industrial television and even community antenna systems have come into being and these have been treated in this revision.



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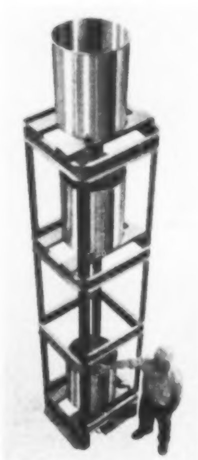

Jet Mixer... showing foot switch, 1/15h.p. motor and 3-way valve. Supplied with plastic lines and hard rubber wheels. Sturdy stainless steel dolly frame for extra strength.

Chemical mixing tower affords pump mixing. Feeder tanks in vertical series saves lab space.

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Fundamental principles remain the same, however, and the authors treat these in Part 1 of the book. Semiconductors, secondary emission, phosphors and electron optics are covered from both the physical and mathematical aspects.

In Part 2 the process of image scanning, sinews of the practical television system, video pickup devices from Nipkow disk to electronic velocity modulation, and picture reproduction from the mechanical beginnings to viewing with storage tubes have been explained.

Part 3 treats in detail the important parts of the modern electronic television system. Interesting in this treatment is information on just how an iconoscope is constructed and processed. These authors should know: they were there at the birth! Numerous other pickup tubes are treated, the image-orthicon, Isocon and Vidicon, to name a few.

The kinescope is similarly treated, with fabricating details as well as necessary engineering data, and a separate treatment of the electron gun. Video amplifiers, with information on required compensations, scanning circuits and synchronization both VHF and UHF television transmitters, transmitting and receiving antennas, and the television receiver with its several kinds of circuits are all also presented.

In Part 4, three full chapters deal with color television — 168 pages. Starting with color fundamentals, the earlier simultaneous and sequential systems are described, followed by such matters as mixed-highs and a full exposition of the present NTSC-evolved now FCC-standard color system. The third color chapter details color apparatus, from camera tubes to receiver screen.

How television has been applied to monitoring industrial processes is quite fully treated, including stereo television. Television as an industry, with emphasis on television broadcasting station construction and operation and notes on networks, concludes the book.

References at the end of each chapter, an author index and a subject index increase the usefulness of the volume, which would seem to be a required reference for anyone seriously interested in television. Besides the engineer and the advanced student, to whom the book has been principally addressed, it would appear that the executive and the research worker would find information of value; the former in acquiring well-organized knowledge on the subject to the depth to which he might be able to go and the latter to insure that his particular endeavors are rightly related to the known art. Patent attorneys and agents should find the book highly useful.—*Harry R. Lubcke*, Registered Patent Agent, 2443 Creston Way, Hollywood 28, Calif.

Acoustics

By Leo L. Beranek. Published (1954) by McGraw-Hill, 330 W. 42 St., New York 36. i–x + 481 pp. Profusely illus. with drawings and graphs. 6 × 9 in. $9.00.

Dr. Beranek states that this book is the outgrowth of a course he has given to seniors and graduate students and the introduction proposes a certain order of presentation in such a course. It is not limited to this purpose, however, for the material is covered in a manner useful to those engaged in the practice of acoustical and allied work.

In the earlier chapters, concerning fundamental concepts, mathematics is necessarily used freely. The author strives to carry along a concurrent physical explanation of these phenomena to aid those (as this reviewer) who are not adept at mathematical analysis. Particular stress is laid on the use of electro-mechanico-acoustical analogies and the concept of acoustic components and circuits. Detailed comparisons of the impedance-type and mobility-type analogies are given to demonstrate the situations where each is most useful.

The instruments of acoustics—microphones and loudspeakers—are treated extensively from the standpoint of design as well as of fundamental operation. A detailed description of design methods for direct radiator loudspeaker enclosures is particularly complete. The differing characteristics of direct radiator and horn-type loudspeakers are elucidated and suitable applications for each are given. Directivity characteristics are emphasized, although no discussion of acoustic lenses is included.

Those subjects concerned more intimately with application of acoustics to human activities are elaborated in the final chapters—acoustics of rooms, meas-

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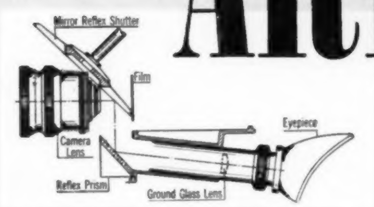

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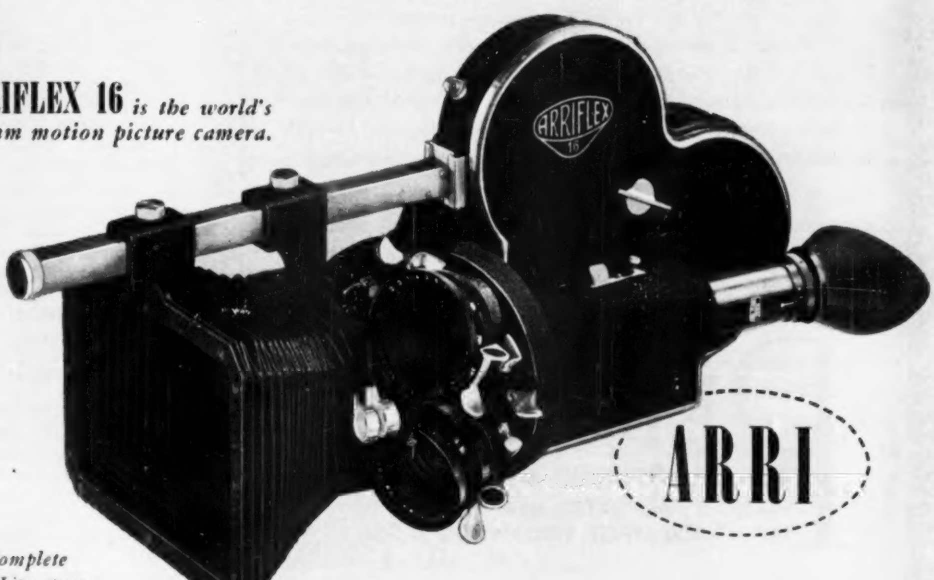

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urement of sound and control of noise, and a discussion of the psycho-acoustic criteria which guide the application of acoustic control methods to field situations. In these chapters, where analysis must often be supplemented or guided by empirically determined quantities, the treatment is less mathematical with many tables and graphs to aid computations.

Throughout the text, illustrative problems are proposed and worked out to demonstrate the application of the methods described. An important feature is the inclusion of 22 pages of problems to be worked by the reader, covering the material of all 13 chapters. The book is well printed for easy reading, with clear tables and figures. Tables of data required for computation are included, together with a comprehensive index. Some references are given, but there has been no attempt to make them a complete bibliography.

This book is an important and welcome addition to the literature of acoustics, and will prove useful to those interested in the application of acoustical principles or associated techniques. Perhaps this is best demonstrated by the fact that this reviewer has found frequent occasion, during the short time it has been in his possession, to consult its pages in the course of his daily work, and has found the answers he sought.—*William B. Snow*, Consulting Engineer, 1011 Georgina Ave., Santa Monica, Calif.

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Books Briefly Noted

Lead Sulphite Films, 19 pp., is Vol. 4, numbered PB 111331, in a series entitled "Metallic Coatings on Non-Metallic Materials," issued by the Office of Technical Services, Rm 6227, U.S. Dept. of Commerce Bldg., Washington 25, D.C. This volume sells for $1.00, was prepared by Samuel Wein, Consultant, and is described as follows in the government's release: In addition to the various processes, discusses applications of lead sulphide films in mirrors, electrical resistance elements, planographic arts, rectifiers and detectors, and light-sensitive cells.

Silver Films, PB 111236, vol. 1 of the series is 138 pp. and sells for $2.00. All other volumes sell for $1.00. In addition to *Lead Sulphide Films* noted above, they are: *Copper Films*, PB 111237; *Nickel Films*, PB 111330; *Gold Films*, PB 111332; *Mechanical Films*, PB 111333; *Metallic Paints for Printed Electronic Circuits and Other Uses*, PB 111334; *Vacuum Coating Methods*, PB 111335; and *Applications of Metal Films on Commercial Products*, PB 111336.

Stills of interest and one in depth are these three books recently published by Morgan & Lester, 101 Park Ave., New York 17.

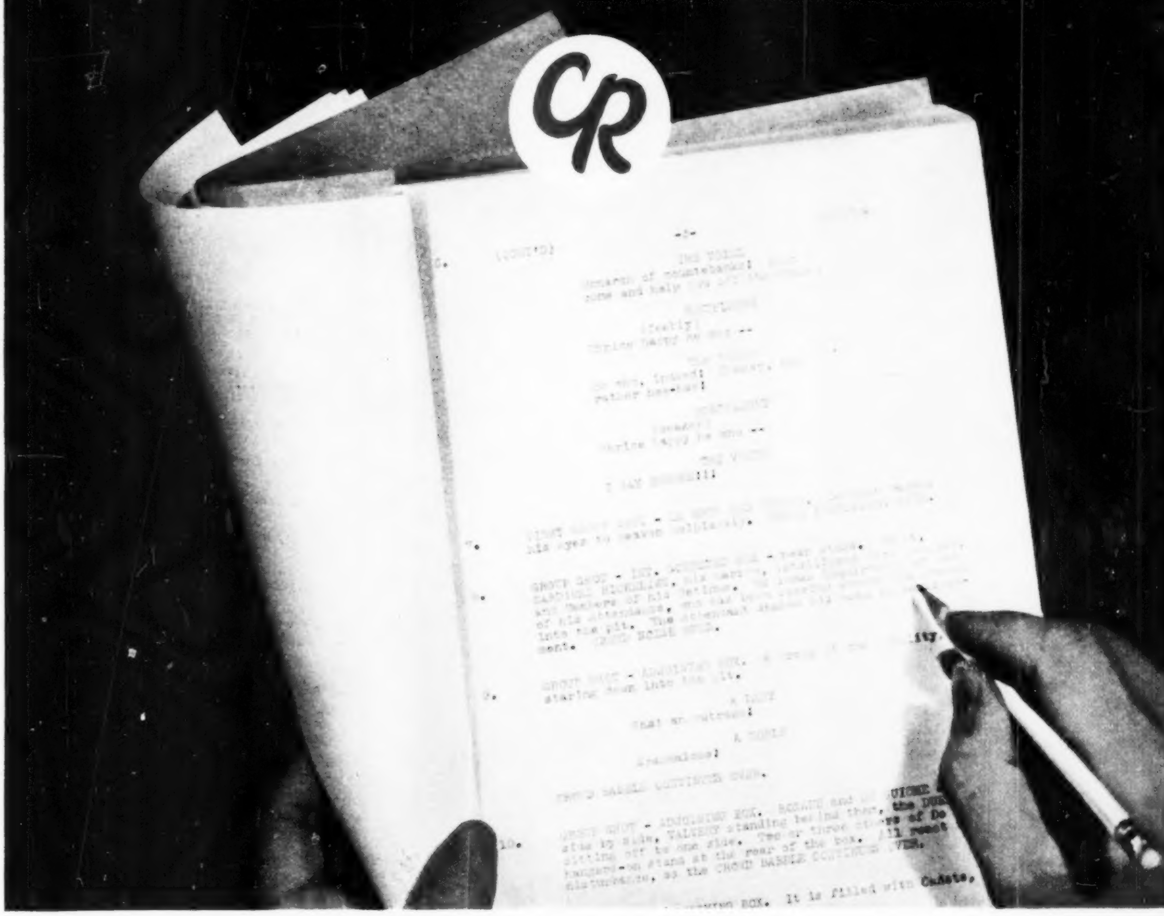
Graphic Graflex Photography is a new version of this well-known book which now includes among its contributors: Ralph M. Evans, Jeannette Klute, Ralph Steiner, Josef A. Schneider, Joseph Costa, Don D. Nibbelink, T. T. Holden, Rudolf Kingslake and Vernon E. Whitman. Although subtitled "The Master Book for the Larger Camera," there is much that is applicable for all still photography. In 6 × 9 in. format, its 432 pp. are profusely illustrated, including 16 pp. in color, and it sells for $6.00.

Photography with the Graflex 22, more fully explained with the subtitle "Better Pictures and More Fun With a Twin-Lens Reflex Camera," by John S. Carroll, is a slighter book but in the same format as the one above. Among the many illustrations in its 128 pp. are 9 in color. The book, being suited to its aim, naturally contains a minimum about the various aspects of photography in general. It sells for $3.00.

Stereo Realist Manual has been written by Messrs. Morgan and Lester aided by 14 stereo experts. They have produced a comprehensive coverage of the possibilities and procedures for this popular 35mm color stereo system. Within the 400 pp. are hundreds of stereo pairs, with two sections in color, to be viewed or studied with the viewer supplied with the book. The price is $6.00.

TV Factbook, now available in the Fall Edition, is a semiannual production of *Television Digest*, edited by Martin Codel. The current compilation is a book of 400 pp., available at $4.00 from Television Digest, Wyatt Bldg., Washington 5, D.C. Contents of previous editions have been listed in this *Journal*. Its wealth of data continues to be amazing in relation to television station and network facilities, licenses, construction permits, applications, discontinued operations, advertising rates, industry ownership and personnel.

This is the time to consult *Cinema Research!*



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What does it cost to produce and distribute a motion picture for advertising or public relations purposes? The Association of National Advertisers, 285 Madison Ave. New York, has published a new book, "*The Dollars and Sense of Business Films*," which for the first time provides heretofore confidential data on actual production, distribution costs and methods for advertising and public relations films produced by 67 of the nation's leading companies. The book sells for $5.00

Based on a survey of 157 nontheatrical films representing a total investment of $12,000,000, this 128-page book gives us the following information:

The typical company spends only 4.6 cents to obtain an average of 26 min of a viewer's time to tell the company's story.

The cost per viewer can drop to as low as 3 mills over the life of the film if a good film is made for a broad, general purpose, audience.

The average film has a long useful life — usually five years, often more.

When films are in circulation for over 10 years, the cost-per-viewer may drop to as low as ½ cent.

It's possible to produce successful nontheatrical films for $25,800, the median cost in this study.

The study shows a film can be expected to reach an audience of 276,036 in a year although audiences of up to 4,548,000 have been booked depending upon the nature of the film story and the target audiences.

Based on the work of the A.N.A. Films Steering Committee, under the chairmanship of John Flory of the Eastman Kodak Co., the book is the result of more than two years' efforts aimed at putting pertinent data in the hands of those people who are investigating the possibilities of nontheatrical motion pictures as a solution to their communications problems.

Second International Symposium on High-Speed Photography and Cinematography

The 1st International Symposium on High-Speed Photography was held in Washington in October 1952 under the auspices of the Society of Motion Picture and Television Engineers.

The 2d Symposium took place in Paris from September 22 to 28 under the sponsorship of the Association Francaise des Ingénieurs et Techniciens du Cinéma (AFITEC), with the British Kinematographic Society, the Deutsche Kinotechnische Gesellschaft and the Samtfundet Svenska Film Ingenjörer acting as cosponsors.

With nearly 200 French members and more than 100 visitors from 18 countries, the Symposium pointed up the increasing interest in photographic methods for the investigation of rapid events in the most varied branches of science and technology, from ballistics to biology, and in such fields as metallurgy, mechanical engineering, aeronautics, electricity, physics and chemistry.

The proceedings comprised 5 lectures and 66 papers distributed into 10 half-day sessions and devoted to experimental methods as well as their applications. Thirty equipment exhibits included almost all commercially available high-speed cameras.

Before reviewing briefly the various technical aspects of the Symposium, two general points may be made.

In the first place, it appears clearly that the use of short exposure-times and high taking rates is not limited to the study of very fast phenomena. The time of exposure should be such that the resulting blur is small compared to the dimension of the subject in the direction of motion. It should therefore be made smaller not only for increasing velocities, but also for decreasing sizes. Thus the study of the process of chip formation at the crystal level requires exposure-times less than 1 μsec and taking rates of about 40,000 frames/sec. A 1% blur on 10 micron droplets travelling at a velocity of only 1 m/sec requires an exposure of 0.1 μsec. Similarly rates in the range of 1,500 to 3,000 frames/sec are necessary if the blood flow is to be observed and its velocity measured.

The rather obvious fact that microscopic observation often can be combined with photography is not always familiar to potential users and should open new fields of application to high-speed techniques.

In the second place, apart from the qualitative results due to the time magnifying property of motion-picture projection, many papers showed the importance of the quantitative information derived from high-speed photographs and frame sequences. This metrologic aspect provides the instrumentation engineer with accurate specifications for image definition in time and space, and requires the development of adequate methods and instruments for record evaluation.

Flash Sources

The electrical and optical properties of electronic flashlamps were reviewed in a lecture by Prof. Laporte. A few particular aspects of gas discharges were studied by W. D. Chesterman (short discharges in xenon), Dr. E. Früngel (demountable high-pressure tubes and triggering method with short delay) and R. Aumont and R. Vodar (guided sparks in compressed gases). W. D. Chesterman emphasized the difficulties of defining flash duration, since exposure time is inseparable from the photographic operating conditions. Interesting details on the definition and measurement of spark-gap deionization time were given by K. Vollrath.

A. Stenzel and K. Vollrath have combined the use of a rotating drum with the Cranz and Schardin multiple-spark arrangement for obtaining a higher number of frames, while H. Luy and R. Schade make use of surface discharges on an electrolyte-impregnated ceramic material in order to record reflexion pictures on a rotating drum.

Special mention should be made of the cathode-ray tube flash generator presented by P. Devaux (Laboratoire Central de l'Armement). Already used by Courtney-Pratt as a light source in connection with his scanning techniques, the cathode-ray tube is now capable of producing flashes of 1 μsec or less sufficiently intense to obtain good transmission images. The high control accuracy of the flashes leads to the construction of so-called "cameras with internal chronometry" of various types, particularly cameras with image-switching by means of a rotating beam or multiple sources.

Finally the present possibilities of flash radiography and high-speed cine radiography were discussed in a paper by G. Thomer, who presented a sealed tube with a life of 1,000 flashes.

High-Speed Shutters

Prof. Karolus studied the various electro-optical effects (Kerr, Faraday and Pockels) and their application as high-speed shutters. The lower limit is of the order of 0.01 μsec for the Kerr effect.

Various shutters were described by Sultanoff, Viard, Walker, Heine-Geldern, Fünfer, and Müller in their papers on ballistic applications.

High-Speed Cameras

The time and space resolution of optical compensation cameras was discussed by R. A. Levy and K. Pfister in their papers on image kinematics and a precision spark-gap time-base. R. A. Levy recommends the use of flash illumination to minimize geometric aberrations.

J. H. Waddell announced a new Fastax 3,000 frames/sec camera with rotating-prism compensation weighing 9 lb and costing less than $1,000.

W. P. Vinten showed the features of the high-definition camera bearing his name (300 frames/sec), while W. J. Sexton examined a number of cameras used for armament and aeronautics research and stressed the need for a 16mm camera rated at 400–500 frames/sec.

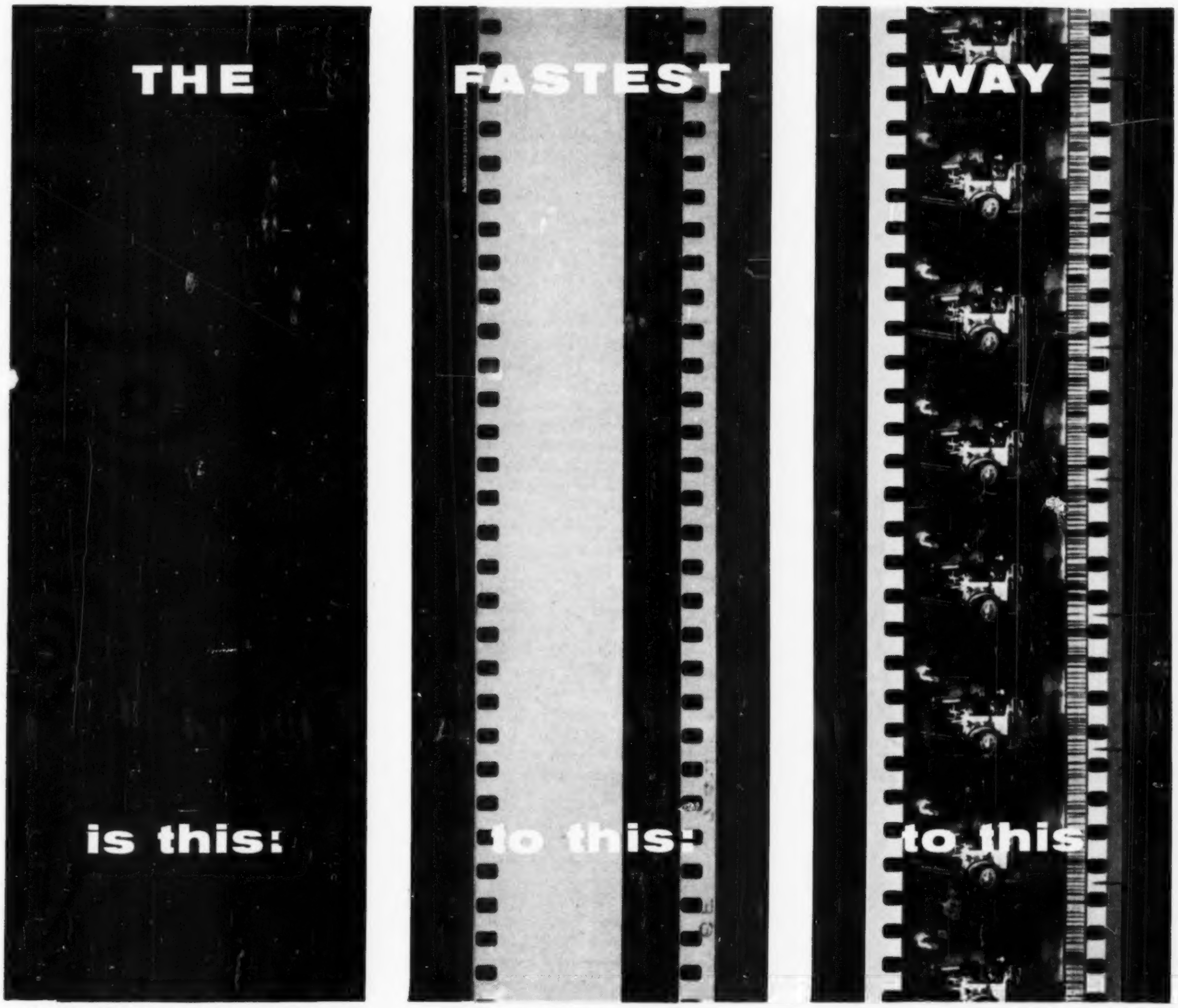
E. W. Walker described a 500,000 frames/sec rotating-beam image-switching camera, the resolution of which is improved by the use of a Kerr-cell high-speed shutter. The rotating mirror of this camera is driven by a pneumatic motor described in a paper by Maj. F. H. Coates.

It is now well known that the principle of image-sampling (or scanning) cameras lies in the possibility of recording on one and the same photographic plate a number of interlaced images consisting of a pattern of lines or dots. The applications of this principle to macro- and microphotography have been studied by Dr. J. S. Courtney-Pratt, D. P. C. Thackeray and G. R. R. Bray. All cameras described make use of the lenticular selector plates made by La Reliéphotographie, Paris. Some of the methods described by Courtney-Pratt and Thackeray make use of a cathode-ray tube as a light source. These authors generally scan the camera objective, while Bray uses a focal-plane scanning method. These papers show a notable improvement in resolution as compared to previous results. The scanning methods make it possible to reach very high taking rates with simple means.

The classification of high-speed cameras was discussed by P. Naslin.

Lighting

The technical characteristics of various light sources for high-speed cinemato-



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graphic work were dealt with by P. T. Cahill, while L. Dawson gave details concerning the special case of tungsten lighting.

Sensitive Surfaces

In a brilliant lecture, Prof. H. J. Frieser discussed the properties of sensitive surfaces for very short exposures and the various aspects of reciprocity failures. He showed that the reciprocity law is again valid for exposure times in the microsecond range, with a reduced sensitivity. He also described the influence of pre- or postsensitization under various developing conditions.

The new Kodak emulsions, particularly the Tri-X, were presented by Mr. de St. Germain.

Applications

J. H. Waddell, F. Van Vyve and Col. Marchal presented a number of films showing the possibilities of commercially available cameras (Fastax, M.G.D. and Kodak) for armament research.

U. Ericsson and Capt. J. R. Dath have made use of spark photography for the study of the influence of air density on the velocity of a detonation and that of the thermal discontinuity surfaces due to the interaction of two shockwaves.

Using the Cranz and Schardin multiple-spark arrangement, W. Struth has been able to determine armor-penetration forces with an accuracy of 10%.

Detonations have been studied by means of Kerr-cell shutters by M. Sultanoff, R. von Heine-Geldern, J. Viard, E. Fünfer and W. Müller. Von Heine-Geldern showed the possibilities of backlighting by means of explosive wires to make visible the metal jet of shaped charges amidst the luminous detonation products. J. Viard makes use of the argon explosive flash-lamp (Muraour's flashes). M. Sultanoff and J. Viard complement the information supplied by high-speed single exposures by space-time recordings on streak-cameras.

X-Ray flashes have been used by R. Schall and G. Thomer for the study of shaped charges and by L. Deffet for that of mining explosives, in conjunction with spark photographs.

Schlieren methods have been used by H. Le Boiteux and E. Curé, also by J. Valensi and Guillaume, for visualizing subsonic and supersonic flows, by L. Pichon and R. Outurquin for studying ram-jet combustion, and by W. Kraus for analyzing mixing and agitating processes. Th. Fromme described an achromatic interferometer of the greatest interest for the study of transient phenomena.

The photo-elastic study of the behavior of materials under dynamic stress was the subject of papers by Prof. H. Schardin, D. G. Christie, Dr. H. Schwieger and F. Zandman. Schardin and Christie make use of the Cranz and Schardin multiple-spark cinematograph for the study of stress and fracture propagation in glass and plastics, while Schwieger records the birefringence photo-electrically for analyzing the shock of two glass-rods. F. Zandman has studied the failure of a notched bar for various locations of the notch with respect to the loading point.

Special mention should be made of the reflection schlieren method used by Prof. H. Schardin and H. Hänsel for studying the elastic and nonelastic surface deformations in metals subjected to dynamic loads. H. Reichenbach makes use of the Cranz and Schardin multiple-spark arrangement for studying the tearing and bursting of plastic sheets.

Atomization processes have been studied by W. Diamant, R. Kling and R. Leboeuf, N. Manson and S. K. Banerjea, F. Deveauvais and L. A. Sackmann; Diamant makes the jet image stationary by means of a rotating mirror, while the others make use of flash illumination.

J. H. Waddell, Allain and de St. Germain showed the possibilities of the Fastax and Kodak high-speed cameras for the investigation of many industrial processes, while M. Leblanc determined the exposure and rate characteristics of a camera for the study of machining processes. K. Pfister observed chip formation on a lathe and coke combustion in a blast furnace, J. Galey and J. Stremsdoerfer the distortion of an ingot during rolling.

J. Brillié and J. Bergougnoux presented the beautiful film of the Air Liquide Laboratories on welding processes in argon.

Finally, stress should be laid on the session devoted to biological and medical applications, which opened with a lecture by Dr. A. R. Michaelis showing applications in anthropology and psychology. J. H. Waddell presented remarkable color films on human vocal chords, ear-drums of cats, the heart of a dog and the human heart. A remarkable film on the human vocal chords, taken at 8,000 frames/sec, was also shown by K. Pfister. Dr. Vallancien compared the use of stroboscopy and high-speed motion pictures for the study of vocal chords. Prof. Piedelièvre and Dr. Michon have derived from high-speed photographs, radiographs and motion pictures interesting conclusions as to the behavior of wounds by fire-arms. Finally, Dr. D. A. McDonald has developed a cinematographic method for measuring the velocity of arterial blood flow.

Interest in such an exchange of information seems to give ample justification for the first two symposia on high-speed photography and cinematography being succeeded by others in the future. For this purpose, a provisional committee for promoting the methods of photographic and cinematographic observation of transient events was set up as an outgrowth of the group already formed by the Organizing Committee of the 2d Symposium and its Foreign Delegates. It was decided that Symposia would be held at 2-year intervals and that the next three would meet in England, Germany and the United States.

The complete Proceedings of the 2d Symposium will be published by the AFITEC. They will sell for between 2000 and 3000 francs, depending on the number of orders received. Orders should be addressed to: The Organizing Secretary, Ing. Ppal P. NASLIN, L. C. A. Fort de Montrouge, Arcueil (Seine), France; payment on delivery. Each paper will be printed in the language chosen by its author (French, English or German); the summaries and figure captions will be printed in all three languages.—*P. Naslin.*

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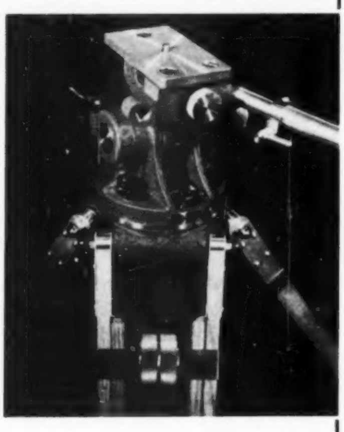

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Proposed Safety Film Regulations in Western Germany

Back in the year 1939 Germany prepared a police regulation prescribing the exclusive use of safety film in theaters. This regulation was not put into effect due to the outbreak of the war. Since then nearly all the large manufacturers of raw film stock in the world have discontinued nitrate base and are manufacturing only safety base for 35mm film. On account of this, Western Germany is preparing a law which will prescribe the exclusive use of safety base and which will eventually form the basis of material simplifications in the planning and construction of motion-picture theaters.

The law will take effect in three stages. Shortly after its publication, which is expected during the latter part of 1954, film laboratories will be permitted to process only safety stock. About three to six months after that, the safety stock will have to show identification marks in such a way and of such kind that proper identification is possible even by the layman. Thereafter several years may elapse before the final stage is reached toward which the law is aiming — that copies on safety stock only may be shown in theaters.

An essential element of the new regulations is the determination of what is considered an adequate identification mark in the sense of the law, which of course will also embody a proper definition of the term "safety base."

The definition closely follows that given in the well-known German Standard DIN 15551. For practical considerations the fixing of a definite nitrogen content is omitted as well as the prescription that the emulsion coating must be removed for the determination of ignition temperature and burning time. The reason for this is that in the case of many recent kinds of film, e.g. color films, the removal of the coating is almost impossible.

All film shall show the mark of the manufacturer along the edge of the film. In addition it will become a legal requirement that a special mark must be placed between the perforations at least every 250 mm. This is similar to the identification mark as adopted by the Eastman Kodak Co. In "Hazard in the Handling and Storage of Nitrate and Safety Motion-Picture Film," the statement is made: "Eastman 35mm black-and-white Safety Motion-Picture Positive Film now carries a lengthwise frame line mark after every fourth perforation located exactly between the perforations instead of at the extreme edge of the film. This is the only area on the film which is ordinarily not exposed in printing."

It is to be expected that, after the issue of the law, laboratories will be asked by the authorities to ensure that exposure of this area will be made impossible in printing practice. As identification marks are proposed: the letter S in regular repetition, "SS," "Nonflamm," or "Safety," the single letters of which would appear on consecutive areas between the perforations. Any other identification mark that might be adopted by some manufacturers to appear in the same areas of the film will probably require a special permit from the legal authorities.

Special consideration has been given to the question of coloring the base by a fluorescent substance or by another color. The use of a fluorescent substance is not favored by some manufacturers. Also the German authorities do not like it since it requires the use of special lamps. A faintly bluish coloring seems to be preferable as it will not interfere with the color of the print in projection and may be easily recognized by daylight or artificial light. It is intended that the use of such a bluish coloration as well as of fluorescent substances will be recommended to manufacturers but will not be made compulsory.

The new law is based on the assumption that DIN 15551 will shortly be issued in a new version which has already been prepared by the Fachnormenausschuss Kinotechnik FAKI and is available in draft form from Benth-Vertrieb, Berlin W 15, Uhlandstrabsse 175.

The above report is contributed by Dr. Leo Busch, formerly technical editor of the magazine *Kinotechnik*. Dr. Busch is now teaching photography and cinematography at the Staatliche Höhere Fachschule für Photographie in Cologne.

THE PROJECTION LIFE OF FILM is largely dependent upon currently engineered sprockets with clean, burr-free teeth. If you use sprockets in the equipment you build, whether it is cameras, printers, developers, projectors, or any other motion picture device, we would welcome the opportunity of working with you on a design to best meet your requirements. Motion Picture Film Sprockets have been a specialty with us since 1908. We can make them for any millimeter film size and in any material. Catalog upon request.

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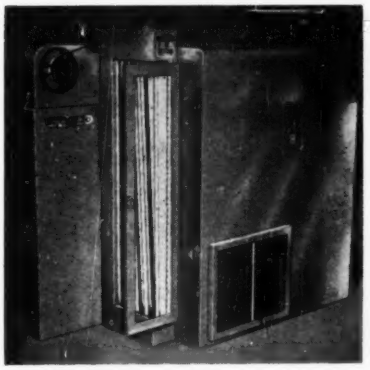
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

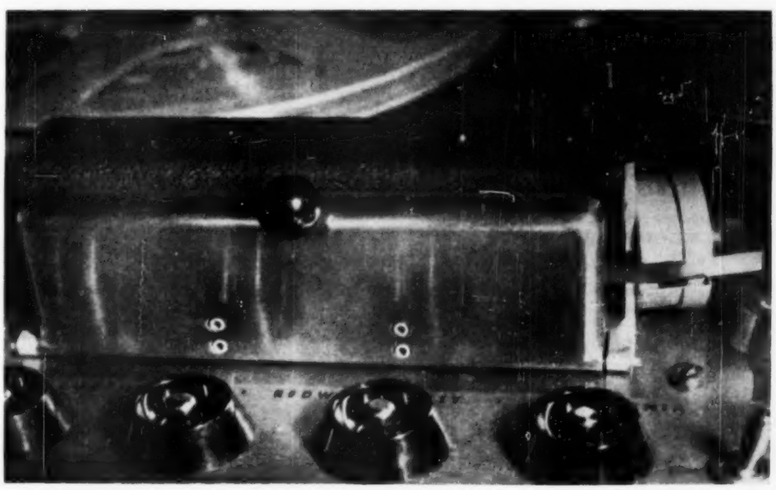


The Bridgamatic Model R-TV is a new rapid, spray-jet 16mm reversal developing machine recently announced by S.O.S. Cinema Supply Corp., 602 West 52 St., New York 19. Originally designed for race tracks so that judges could spot fouls a few minutes after the end of a race, it is now being installed for television stations, with news events films reported developed and ready for screening within 3 min. It operates at about 100 degrees and up to 85 ft/min. It is water-jacketed throughout with immersed tubing to preheat chemicals for faster action in the pressurized jet spray developer. Elevators have been eliminated by use of a patented over-drive to speed operation. Only 100 ft of leader is used. The drybox is designed to hold only 28 ft of film, to be dried in a few seconds after leaving the wash by 120° filtered air. The machine has a 400-ft magazine to take loading spools right from the camera. It is designed for automatic daylight operation and is installed with 18 sq ft of floor space.

A method of synchronizing ¼-inch magnetic tape has been developed by Rangertone, Inc., to meet the interest in it for motion-picture sound recording not only for originals but also for safeties especially when doing final mixes.

The special feature of this synchronizing method is the use of an additional recording head to the right of the usual heads as shown in the illustration. This head makes a balanced recording in the center of the tape of a small part of the voltage driving the camera motor; then this recording serves as a means of holding the tape in strict step on playback even though there are no sprocket holes. The main feature reported, however, is that the full dynamic sound possibilities of the tape are left unimpeded to give the best possible recording.

This system is available not only on Rangertone equipments but also may be applied to any professional tape recorder. Standard adaptations are reported by Rangertone as made on RCA, Ampex, Magnecord and Presto recorders. For most installations where recording the sound is all that is required, installation of this head and the associated control circuits adds little weight, for no extra boxes or cords are added. Such adaptations cost about $300, depending upon the recorder. The recorders are shipped to Rangertone, Inc., 73 Winthrop St., Newark 4, N.J., and are reported to be converted and reshipped within 48 hr. There are Rangertone equipments to accomplish transfer points for carrying the good sound to either 35mm or 16mm film, and these, depending upon the type of recorder, cost about $2000.



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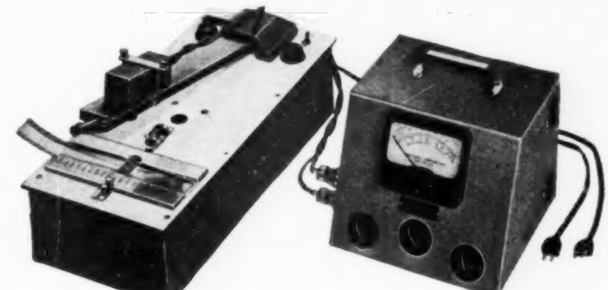
for measurement of density on sound track of 35mm and 16mm motion picture film and for evaluation of sensitometric step-tablets



Suitable also for general black-and-white and color densitometry

Write for Bulletin No. 245 — **Price, complete $445**

The instrument is also available with Multiplier Photometer Mod. 520-A (additional price $230) for color densitometry with sharp-cutting narrow-band interference filters

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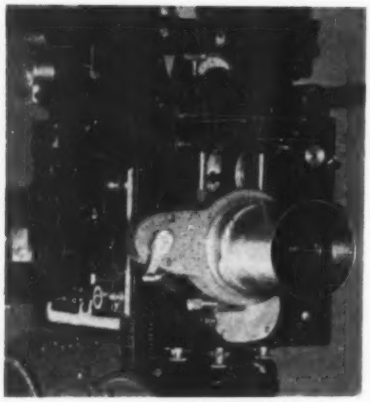
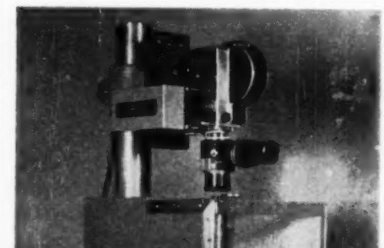


A rotating lens adaptable to 16mm and 35mm motion-picture and television cameras for the purpose of reproducing images at any angle is being offered by the Camera Mart, Inc., 1845 Broadway, New York 23. By cranking the handle of the revolving housing, a subject or scene may be shown revolving slowly or rapidly, clockwise or counterclockwise. Or by cranking the handle gently back and forth, shipboard motion may be suggested, The Rotator Lens will fit into the revolving housing of the Camart Optical FX Unit for most 16mm and some 35 mm cameras and can be used with the camera baseplate and double arm assembly provided with the complete unit. Shown here is a Rotator Lens as used on the Mitchell 35mm Standard Camera. There are special adapters for TV cameras.

The Emdeco Model CU-236 Cinephotomicrograph Time Lapse Assembly is announced by the Electro-Mechanical Development Co., 2337 Bissonet, Houston, Tex. This equipment was designed for the purpose of automatically photographing under a microscope any material, transparent or opaque, which involves a time change in the material. In special applications, a temperature-controlled chamber or incubator may be used to enclose a microscope. For other applications, the specimen may be heated or cooled while the photography is in progress. Bolex, Cine Kodak or Bell & Howell standard 16mm cameras may be used. The capacity of the camera is 4,000 pictures with one load (100 ft of 16mm film). The unit will automatically photograph the subject material at uniformly spaced predetermined intervals, usually at a rate of 16 frames/min or less. The processed 16mm film is then projected at a normal frame speed of 8, 16 or 24 frames/sec, showing changes representing hours at normal rate in a matter of minutes.

The camera mount base plate is attached at the top of the 5-ft steel stand for positioning above the microscope. The camera drive mechanism, which advances the film one frame per pulse, closes the shutter of the camera and turns off the illuminator after each exposure, is actuated by the timing and control box. This device provides selection of 1, 2, 4, 8 and 16 frames/min. The complete assembly including a Bolex camera, costs $1,133.



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			Code
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2. Multifrequency Reel	40 to 12,000 cycles, 4-track	425 ft.*	(MF-1)
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4. Stereophonic Reel	Picture with stereo sound and 12,000-cycle control signal on track four	330 ft.*	(ST-1)
5. Flutter Film	3000-cycle, 4-track	50 ft.	(FL-1)
6. Loudspeaker Phasing Film	Signal of uniform level, 400-cycle or 500-cycle frequency-warbled simultaneously on tracks 1, 2, and 3, at a 5-cycle rate (specify crossover frequency desired)	50 ft.	(LP-1)
7. Constant Level Film	8000-cycle, 4-track to check azimuth	50 ft.	(AZ-1)
8. Channel-Four Film	12,000/1000 cycle	50 ft.	(CH-4)
9. Projector Alignment Chart	Picture Only	100 ft.	(PR-1)
10. Projector Alignment Chart—Optical Track	Picture only, standard sprocket holes (made by Motion Picture Research Council)	100 ft.	CSOS

*These lengths approximate.

BASIC SET consists of types 1, 2, 7 and 9. This group is a "must" for every theater service engineer.

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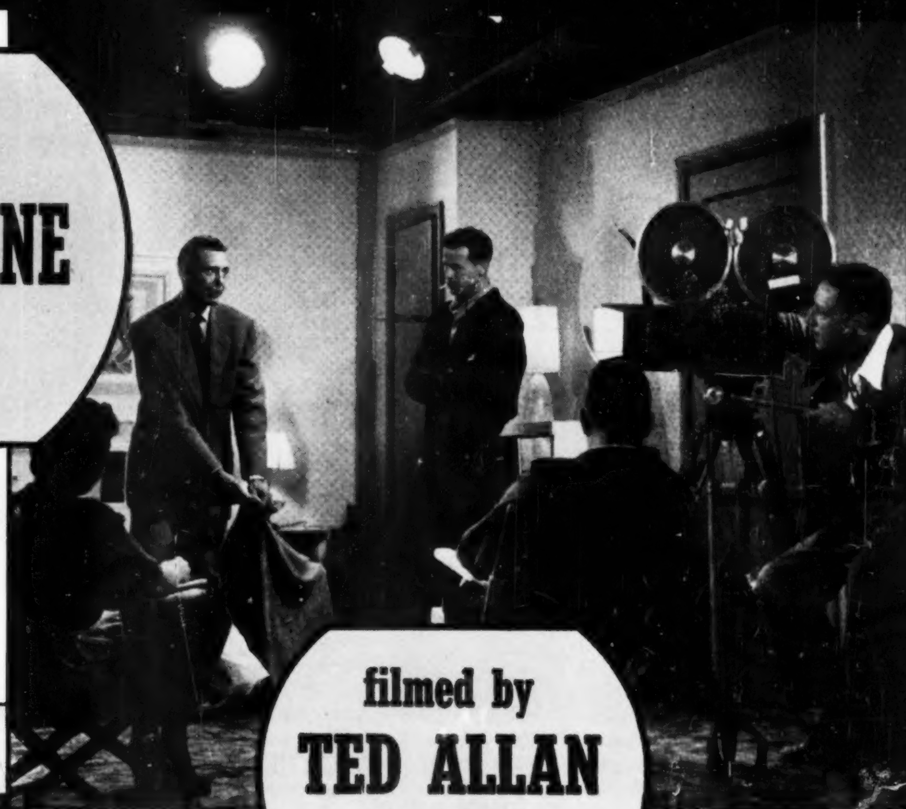
The HANK McCUNE TV Show

HANK McCUNE



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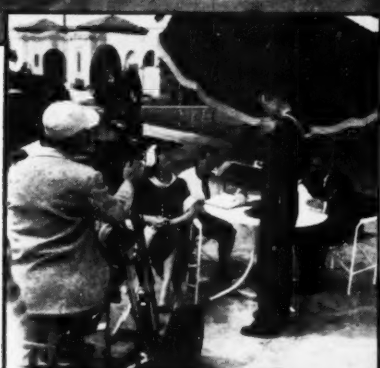

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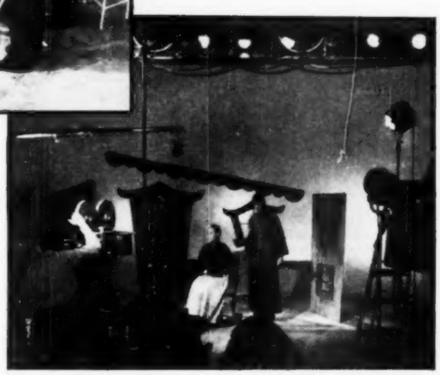
Filmed at Destroyer Base Reception Center, San Diego, California, with cooperation of the United States Navy.



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16mm Sound-on-Film Camera!

Ted Allan, veteran Hollywood Photographer of the Stars, is one of the many professional film producers whose first choice for dependable television filming of the highest quality, is an Auricon 16mm Camera.

The "Hank McCune Show," a comedy series soon to be seen by millions over national TV networks, is being filmed in natural color with the "Super 1200" Camera. Ted Allan says, "45,000 feet of film have been run through the Auricon Camera without a film-scratch or loss of a foot of film!"

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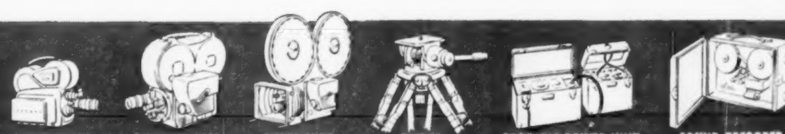

Theatre Network Television, Inc., 575 Madison Ave., New York 22, announces that it has purchased 50 theater-screen television projection units designed and manufactured for hotel closed-circuit television by General Precision Laboratory Inc. This new equipment will make possible simultaneous closed-circuit business meetings in as many as 50 hotels located in 50 different cities from coast to coast, and will augment TNT's current network of over 100 theaters.

The equipment, known as model PB 610, provides adjustable pictures ranging in size from 4 × 6 ft to 9 × 12 ft, giving television viewing for audiences numbering anywhere from 50 to 500 or more people. In addition, the transaction includes some of GPL's standard theater television projection units which will provide pictures from 9 × 12 ft to 24 × 36 ft, to be used in the largest hotel ballrooms and theaters accommodating 1000 people or more. Installation and service for the new equipment will be in the hands of the RCA Service Co., Inc.

Society members have for many years purchased attractive hand-engrossed membership certificates for display in their offices or homes. These certificates were always priced, at least as far back as the records go, at $1.50. This is now less than their cost and so it has been necessary to increase the price of certificates effective October 1, to $2.50.

Lighting equipment is again covered very extensively in the latest catalog, catalog D, released by Mole-Richardson Co., 939 N. Sycamore Ave., Hollywood 38, Calif. In addition to illustrating and describing extensively the many items of equipment the company manufactures, the catalog contains numerous photographs showing actual use of equipment in interesting setups on the sound stages of major motion-picture studios, industrial film producers and television film makers. Other sections are devoted to useful data on power distribution, showing amperage consumption, amperage carrying capacity of cables and typical three-wire and two-wire distribution systems; lighting for color photography; globe characteristics; and illumination tables showing light intensity and spot diameter for spot lamps and flood lamps.

Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Motion Picture Production. Desire position as assistant to producer. Background includes camera experience, some directing in 35mm productions. Age 24. Write: Harry Wuest, 137 Summit Ave., Upper Montclair, N.J.

Electronic Engineer. 20 yrs experience in all phases of audio; responsible for prominent part in development of the Perspecta stereophonic system; comprehensive experience in technical education, classroom, laboratory and the preparation of textbooks and technical literature; advanced training in economics and industrial administration; many responsible posts held. British born, came to U.S. July 1953. Active member I.E.E., I.R.E., A.E.S., SMPTE. Seeks progressive position in West. Write: Norman H. Crowhurst, 150-46 18th Ave., Whitestone 57, N.Y.

16mm Motion-Picture Production. Would like position with aggressive, responsible firm with opportunities for advancement. Have been operating own film company majoring in TV film commercials but am now liquidating as present market holds little future. Has been mainly one-man operation: selling, writing, producing, billing and collecting. Have had successful business but area offers no future for advancement. Will send audition film. Will make permanent move only. Age 28. Write: M. R. Young, T-V Commercial Films, 1215 No. Copia St., El Paso, Texas.

Positions Available

Timers, color and/or black-and-white film required by motion-picture laboratory. Supervisory experience or ability desired. Send resume and small photograph to Du Art Film Labs, Inc., 245 West 55 St., New York 19.

Photographic Equipment Technologist, $5940 per year. Applicants must have bachelor's degree in technology, engineering or one of the physical sciences, plus 3 yr professional experience of a scientific or technical nature, including 2 yr of difficult and important work in the technology of photography; *or* 4 yr experience, demonstrating a mastery of the fundamental physical and mathematical sciences underlying professional technological work and a theoretical and practical understanding of the application of those sciences to photography which is comparable to that acquired by completion of a standard technological or scientific curriculum in an accredited college, may be substituted for the required bachelor's degree. Write: David A. Lana, Head, Industrial Relations Dept., Office of Naval Research, Special Devices Center, Port Washington, N.Y.

Motion-Picture Laboratory Technician (Sensitometry), GS-8, $4620 per year. Applicants must have at least 4½ years experience in all phases of motion-picture film processing in black-and-white and color. Position requires ability to handle quality control in processing and to make recommendations for and assist in improving the product. Further information from MCGCER, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio.

Photographic Sales Technician. Require competent technician with at least two years' college chemistry and phototechnical school training or equivalent. Must have thorough knowledge of black-and-white, color, studio, and photofinishing techniques. Must show definite interest in sales and willingness to travel. Send brief resume, including approximate salary requirements, to Gerald G. Wood, Ansco, 29 Charles St., Binghamton, N.Y.

Laboratory Technician with years of experience and thorough knowledge of all phases of motion picture laboratory work—as assistant to plant superintendent. **Sensitometric Control Man** with thorough background and experience—full responsibility. **Sound Engineer** to maintain and operate magnetic and optical re-recording equipment. Applicants should contact: Herbert R. Pilzer, Circle Film Laboratories, Inc. 33 West 60th St., New York 23. Tel. Co 5-2180

35mm Motion Picture Service Man. Openings in this country and Europe; experience not required if engineering graduate or if experienced in similar field. Apply to Army & Air Force Motion Picture Service, Engineering Depot, Building 207-C, 4300 Goodfellow Blvd., St. Louis 20, Mo.

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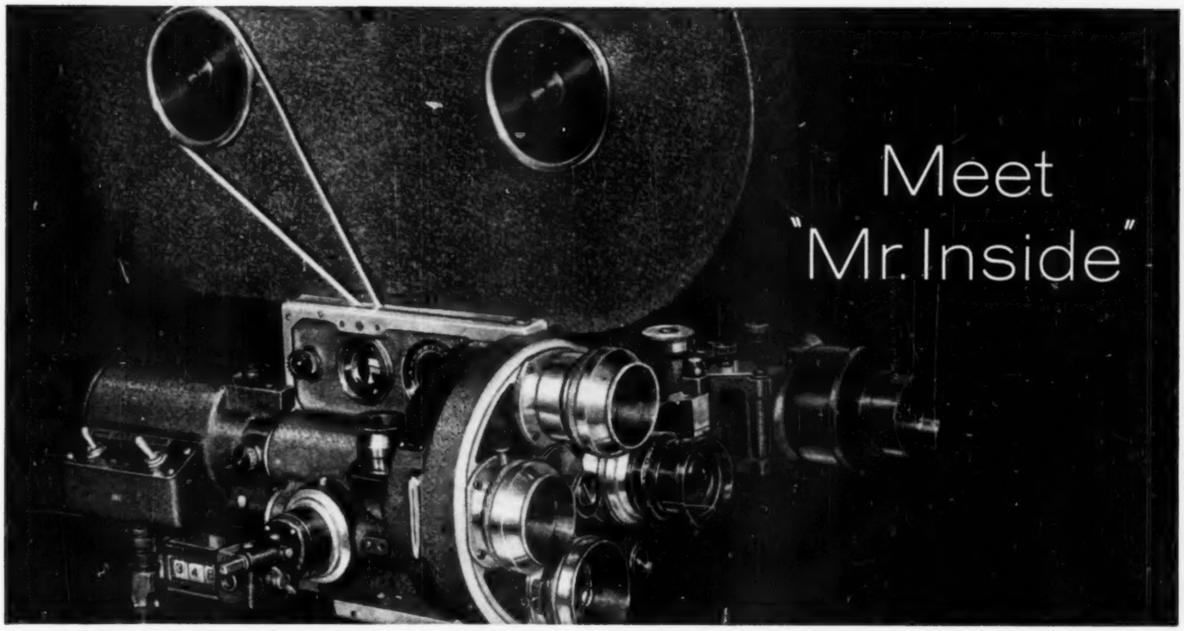

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Contents — pages 198–216

Journals Available and Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Journals from July 1948 through December 1954, including symposiums, directories, indexes, etc. Excellent condition. $30.00 FOB. Write Hal Magargle, 4812 Cooper Lane, Hyattsville, Md.

Dec., 1936; Jan., Feb., Apr., May, July, Sept., Nov. 1937; 1938 complete; 1939 complete; 1940 complete; Jan.–Aug. 1941. Write Richard S. Norton, Warner News Inc., 625 Madison Ave., New York, 22.

Collection of back issues available either singly or as a lot. Write F. H. Cole, 1252 So. Burnside Ave., Los Angeles 19.

High-Speed Photography, Volumes 1, 2 and 3. Write Jack Gorham, Armour Research Foundation, Technology Center, Chicago 16.

Transactions Nos. 6 and 9. Write W. W. Hennessy, 593 West 41 St., New York.

Wanted

Complete set of Transactions. Write John Flory, Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

Signal Corps Pictorial Center could use a complete set of Journals, preferably as a donation. Write John P. Byrne, Motion Picture Sensitometrics, Signal Corps Pictorial Center, 45-15 48 St., Long Island City 4, N.Y.

Transactions Nos. 1, 5, 6, 7 and 9. Write Lloyd E. Varden, Pavelle Color Inc., 533 West 57 St., New York 19.

Meetings

SMPTE Central Section, Nov. 15, Dec. 13; Jan. 17, Feb. 21, Mar. 21, May 16, June 13, 1955.

Acoustical Society of America, Nov. 18–20, Austin, Texas

77th Semiannual Convention of the SMPTE, Apr. 17–22, 1955, Drake Hotel, Chicago

The International Commission on Illumination is to hold its next international conference in Zurich, Switzerland, June 13–22, 1955. Offers of papers should be addressed to the Chairman of the Papers Committee (K. A. Brainerd), 1015 Chestnut St., Philadelphia 7. Manuscripts must be in the hands of the Central Bureau between Oct. 1 and Dec. 31, 1954.

Biological Photographic Association, Annual Meeting, Aug. 30–Sept. 2, 1955, Wisconsin Hotel, Milwaukee.

78th Semiannual Convention of the SMPTE, Oct. 3–7, 1955 (next year), Lake Placid Club, Essex County, N.Y.

Photographic Society of America, 1955 Convention, Oct. 5–8, 1955, Sheraton-Plaza Hotel, Boston, Mass.

79th Semiannual Convention of the SMPTE, Apr. 29–May 4, 1956, Hotel Statler, New York

80th Semiannual Convention of the SMPTE, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles

81st Semiannual Convention of the SMPTE, Apr. 28–May 3, 1957, Shoreham Hotel, Washington, D. C.

82nd Semiannual Convention of the SMPTE, Oct. 6–11, 1957, Hotel Statler, New York

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April Journal.

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